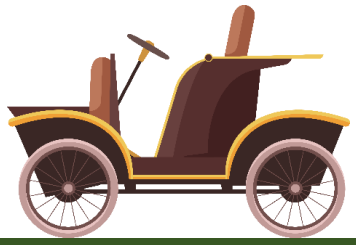
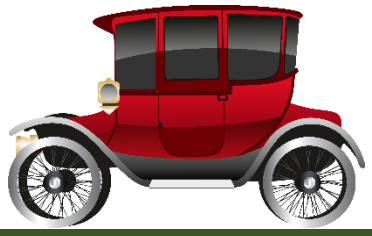
Draft Study Material





Electric Vehicle Service Assistant

(Job Role)

Grade IX

विद्यया ऽ मृतमश्नुते

एन सी ई आर टी
NCERT

PSS CENTRAL INSTITUTE OF VOCATIONAL EDUCATION,
(a constituent unit of NCERT, under MoE, Government of India)
Shyamla Hills, Bhopal- 462002, M.P., India
http://www.psscive.ac.in

Preface

Vocational Education is a dynamic and evolving field, and ensuring that every student has access to quality learning materials is of paramount importance. The journey of the PSS Central Institute of Vocational Education (PSSCIVE) toward producing comprehensive and inclusive study material is rigorous and time-consuming, requiring thorough research, expert consultation, and publication by the National Council of Educational Research and Training (NCERT). However, the absence of finalized study material should not impede the educational progress of our students. In response to this necessity, we present the draft study material, a provisional yet comprehensive guide, designed to bridge the gap between teaching and learning, until the official version of the study material is made available by the NCERT. The draft study material provides a structured and accessible set of materials for teachers and students to utilize in the interim period. The content is aligned with the prescribed curriculum to ensure that students remain on track with their learning objectives.

The contents of the modules are curated to provide continuity in education and maintain the momentum of teaching-learning in vocational education. It encompasses essential concepts and skills aligned with the curriculum and educational standards. We extend our gratitude to the academicians, vocational educators, subject matter experts, industry experts, academic consultants, and all other people who contributed their expertise and insights to the creation of the draft study material.

Teachers are encouraged to use the draft modules of the study material as a guide and supplement their teaching with additional resources and activities that cater to their students' unique learning styles and needs. Collaboration and feedback are vital; therefore, we welcome suggestions for improvement, especially by the teachers, in improving upon the content of the study material.

Deepak Paliwal
(Joint Director)
PSSCIVE, Bhopal

Date: 20 June 2024

STUDY MATERIAL DEVELOPMENT COMMITTEE

Members

1. Mr. Ankit Singh Chauhan, Assistant Professor, Automotive, Department of Engineering and Technology, PSS Central Institute of Vocational Education, Shyamla Hills, Bhopal, M.P.- 462002
2. Mr. Abhishank Jain, Director, Founder at Abhishank Technologies Pvt. Ltd., Noida, Uttar Pradesh, India.
3. Mr. Kuber Singh, Consultant, Department of Mechanical Engineering, AISECT University Bhopal.
4. Mr. Pankaj Tiwari, Director, NXTE mobility, Gautam Buddha Nagar, Uttar Pradesh, India.
5. Mr. Sudhir Kumar Vishwakarma, Consultant, CRISP, Opposite Manas Bhawan, Shyamla Hills, Bhopal- 462602
6. Mr. Uday Ganesh Paradkar, General Manager, CI Hyundai Trainer, Misrod Bhopal.
7. Dr. Vinod Kumar Yadav, Associate Professor, Department of Engineering and Technology, Pandit Sunderlal Sharma Central Institute of Vocational Education (PSSCIVE), Shyamla Hills, Bhopal (M.P), India.

Member Coordinator

Dr. Saurabh Prakash, Professor, Department of Engineering and Technology, Pandit Sunderlal Sharma Central Institute of Vocational Education (PSSCIVE), Shyamla Hills, Bhopal (M.P), India.

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Module 1	Introduction of Electric Vehicles in India

Module Overview

In India, Electric Vehicles (EVs) are rapidly becoming popular and viable forms of transportation. In addition to providing environmental benefits, EVs provide economic benefits as well. Several EVs have been introduced in India over the past few years. Electric Vehicles (EVs) are gaining popularity around the world as sustainable alternatives to traditional gasoline-powered vehicles. EVs have many benefits over petroleum fuels such as, they do not emit emissions, are much quieter than traditional cars, and are far more efficient in terms of energy use.

An Electric Vehicle (EV) is a type of vehicle that runs on electricity stored in rechargeable batteries rather than gasoline or diesel fuel. The batteries power an electric motor that drives the wheels, propelling the vehicle forward.

In this Module, we will explore the history of Electric Vehicles (shows as Fig. 1.1), the current state of the industry, and the potential for EVs to transform the way we travel. We will also discuss the challenges and opportunities presented by this rapidly evolving field and explore the role that Electric Vehicles could play in creating a more sustainable future.

Fig.1.1: Electric Vehicle

Learning Outcome

After completing this module, you will be able to:

1. Understand the origins and evolution of Electric Vehicles (EVs).
2. Evaluate the challenges and solutions related to the environmental sustainability of EVs.
3. Understand the current state and growth trajectory of the EV market in India.
4. Identify key policies, incentives, and initiatives by the Indian government to promote EV adoption.
5. Analyse the challenges and opportunities in the Indian EV ecosystem, including infrastructure development and market dynamics.
6. Understand the essential roles and responsibilities of an EV service assistant.

Module Structure

Session 1: History of Electric Vehicles
Session 2: The Environmental Impact and Electric Vehicles
Session 3: Electric Vehicle Scenario in India
Session 4: Role and Duties of EV Service Assistant

Session 1: History of Electric Vehicles

First Electric Car in History

The development of Electric Vehicles was the result of numerous advancements and enhancements. A crucial contributor to this field was *Ányos Jedlik*, a Hungarian inventor and engineer who invented the world's first electric motor around 1828, which he subsequently applied to a miniature car. During the same period, *Thomas Davenport*, an American blacksmith, built a similar device in 1834 that operated on an electrified circular track.

However, ***Robert Anderson***, a Scottish entrepreneur and chemist, is widely regarded as the father of the electric car as he worked on and introduced a prototype between 1832 and 1839, which was a modernised version of a conventional carriage that was powered by electric cells.

Over the years, various models of electric cars have been developed, but the non-rechargeable battery technology made them impractical. However, in 1859, French scientist *Gaston Planté* developed rechargeable lead-acid batteries that enabled electric cars to store energy and run without being connected to the grid. Later, in 1881, *Camille Faure* improved the battery charging capacity, leading to the development of electric tricycles by *Gustave Trouvé*, which were showcased at the International Electricity Exhibition in Paris. These breakthroughs paved the way for the advancement of Electric Vehicles.

Fig. 1.2: First Electric Vehicle

Fig. 1.3: Thomas Parker Electric car

The ***Flocken Elektrowagen***, invented by *Andreas Flocken*, is considered the first electric car and was introduced in Germany in 1888. It had a buggy-like design with four wheels, a 0.7 kW motor, a 100 kg battery, and could travel at a maximum speed of 15 km/h. In 1899, ***Camille Jenatzy*** from Belgium made history by breaking the world speed record and reaching a speed of 105.88 km/h, marking a significant milestone in the automotive industry.

When did electric cars come into use?

Following the arrival of the rechargeable battery, the electric car became a hit in early 20th-century cities. The first commercial users were New York taxi drivers. Some historians estimate that around one-third of the cars on the streets of the United States were electric in 1900, while some sources claim that these vehicles outsold combustion engines in 1899 and 1900. Among the vehicles sold were the Porsche Egger-Lohner P1 and the Baker Electric, and among the manufacturers, Ohio Baker Electric, which had batteries designed by Thomas Edison.

Here is a timeline highlighting the key developments in the development of Electric Vehicles:

- In1828, Hungarian inventor Ányos Jedlik built a small-scale electric car, considered one of the earliest Electric Vehicle prototypes.
- In 1834, Thomas Davenport, an American blacksmith, invented the first practical electric motor, leading to the development of Electric Vehicles.
- In 1859, French physicist Gaston Planté invented the lead-acid battery, which became a crucial power source for early Electric Vehicles.
- In 1881, Gustave Trouvé, a French electrical engineer, showcased an electric tricycle at the International Exhibition of Electricity in Paris.
- In 1993, India saw the debut of its first electric car, the "Lovebird," featured a DC motor powered by a lead-acid battery and a four-speed gearbox.
- In 1996, Scooter's India Pvt Ltd launched India's first electric three-wheeler called the "Vikram Safa."
- In 2000, BHEL unveiled India's first electric bus, capable of seating 18 passengers and powered by a lead-acid battery.
- The tide turned with the introduction of India's first successful electric car, the "REVA," by the Reva Electric Car Company (RECC) in 2001.
- In 2006, Tesla Motors unveiled the Tesla Roadster, an all-electric sports car that uses lithium-ion batteries, marking a significant milestone in Electric Vehicle development.
- In 2018, ride-hailing giant Ola announced its ambitious plan to add 1 million Electric Vehicles to its platform by 2021
- In 2020, The Electric Vehicle market experiences substantial growth globally, with numerous automakers launching electric models to meet increasing demand.

The timeline demonstrates the long history of Electric Vehicles, with recent years witnessing significant advancements in technology, increased consumer acceptance, and governmental support. The development of Electric Vehicles continues to progress rapidly as the world moves toward a more sustainable and electrified transportation future.

CHECK YOUR PROGRESS

A. Fill in the Blanks

1. An _____ is a type of vehicle that runs on electricity stored in rechargeable batteries rather than gasoline or diesel fuel.
2. _____ a Scottish entrepreneur and chemist, is widely regarded as the father of electric cars.

B. Multiple Choice Questions:

i. What type of vehicle was the Flocken Elektrowagen?

a) Sedan
b) Buggy
c) Sports car
d) SUV

ii. In which year did Camille Jenatzy break the world speed record with an electric car?

a) 1828
b) 1888
c) 1899
d) 1900

iii. Which scientist developed the rechargeable lead-acid batteries for electric cars?

a) Ányos Jedlik
b) Thomas Davenport
c) Gaston Planté
d) Robert Anderson

iv. Which city's taxi drivers were among the first commercial users of electric cars in the early 20th century?

a) New York
b) London
c) Berlin
d) Paris

v. Which company manufactured Electric Vehicles with batteries designed by Thomas Edison?

a) Porsche
b) Baker Electric
c) Flocken Elektrowagen
d) Ohio Baker Electric

C. Answer the Following Questions:

1) Who is credited with inventing the world's first electric motor and applying it to a miniature car?
2) What type of device did Thomas Davenport build in 1834 that operated on an electrified circular track?
3) Who is widely regarded as the father of the electric cars for introducing a prototype of a conventional carriage powered by electric cells?
4) Which scientist developed rechargeable lead-acid batteries, enabling electric cars to store energy and run without being connected to the grid?
5) Which year and country saw the introduction of the Flocken Elektrowagen, considered the first electric car?

Activity

1. Make a list of the types of electric vehicles available in the market in your city.
2. Collect pictures of electric vehicles with their specifications.
3. Compare an Electric Vehicle (manufactured in India) With a conventional Vehicle (manufactured in India).

Session 2: The Environmental Impact and Electric Vehicles

Role of present automobile vehicles on our environment

The automotive industry and the other industries that serve it constitute the backbone of the word's economy and employ the greatest share of the working population. The large number of automobiles in use around the world has caused and continues to cause serious problems for the environment and human life. Air pollution, global warming, and the rapid depletion of the earth's petroleum resources are now problems of paramount concern. The research and development activities related to transportation have emphasised the development of high efficiency, clean, and safe transportation.

According to a report by India Government says that India can reduce energy demand by 64% and Carbon emissions by 37% with the help of connected, shared and electric passenger mobility across the country by 2030.

India, at the 26th session of the United Nations Framework Convention on Climate Change (COP 26) in November, 2021, announced its target to achieve net zero by 2070.

Air Pollution

At present, all vehicles rely on the combustion of hydrocarbon fuels to derive the energy necessary for their propulsion. Combustion is a reaction between the fuel and the air that releases heat and combustion products. A Hydro-Carbon is a chemical compound with molecules made up of Carbon and Hydrogen atoms. Ideally, the combustion of a Hydro-Carbon yields only Carbon Dioxide and water, which do not harm the environment. Besides Carbon Dioxide and water, the combustion products contain a certain amount of Nitrogen oxide (NOx), Carbon monoxide (CO), and unburned Hydro-Carbons (HC), all of which are toxic to human health.

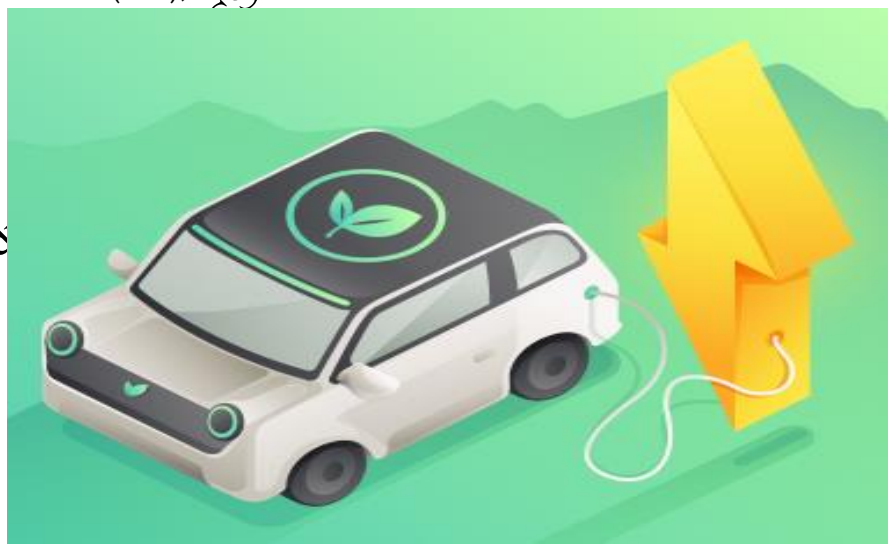


Fig. 1.4: Free from Air pollution

Nitrogen Oxides

Nitrogen Oxides (NO_x) result from the reaction between nitrogen in the air and oxygen. However, the high temperatures and pressures in engines create favourable conditions for the formation of nitrogen oxides. Temperature is by far the most important parameter in the formation nitrogen oxide formation. The most commonly found nitrogen oxide is Nitric Oxide (NO), although small amounts of Nitrogen Dioxide (NO_2) and traces Of Nitrous Oxide (N_2O) are also present. Once released into the atmosphere, NO reacts with Oxygen to form NO_2. This is later decomposed by the Sun's ultraviolet radiation back to NO and highly reactive oxygen atoms that attack the membranes of living cells. Nitrogen Dioxide is partly responsible for smog; its brownish colour makes smog visible. It also reacts with atmospheric water to form nitric acid (HNO_3), which dilutes in rain. This phenomenon is referred to as "acid rain" and is responsible for the destruction of forests in industrialised countries.

Carbon Monoxide

Carbon monoxide results from the incomplete combustion of Hydro-Carbons due to a lack of oxygen. It is a poison to human and animal beings that breathe it. Once Carbon monoxide reaches the blood cells, it fixes to the haemoglobin in place of oxygen, thus diminishing the quantity of oxygen that reaches the organs and reducing the physical and mental abilities of affected living beings. Carbon monoxide binds more strongly to haemoglobin than oxygen. The bonds are so strong that normal body functions cannot break them. Persons intoxicated by Carbon monoxide must be treated in pressurised chambers, where the pressure makes the Carbon monoxide–haemoglobin bonds easier to break.

Unburned Hydro-Carbons

Unburned Hydro-Carbons are a result of the incomplete combustion of Hydro-Carbons. Some of these unburned Hydro-Carbons may be direct poisons or carcinogenic chemicals such as particulates, benzene, or others.

Unburned Hydro-Carbons are also responsible for smog: The Sun's ultraviolet radiations interact with unburned Hydro-Carbons and NO in the atmosphere to form Ozone and other products. Ozone is a molecule formed of three oxygen atoms. It is colourless but very dangerous, and poisons as it attacks the membranes of living cells, thus causing them to age

greatly from exposure to high ozone concentrations. Annually, many deaths from high ozone peaks in polluted cities are reported.

Other Pollutants.

The major impurity is sulphur, which is mostly found in diesel and jet fuel and also in gasoline and natural gas. The combustion of sulphur (or sulphur compounds such as hydrogen sulphide) with oxygen releases sulphur oxides (SO_x). Sulphur Dioxide (SO_2) is the major product of this combustion. Upon contact with air, it forms sulphur trioxide, which later reacts with water to form sulfuric acid, a major component of acid rain. It should be noted that sulphur oxide emissions originate from transportation sources, but also largely from the combustion of coal in power plants and steel factories.

Advantages of using Electric Vehicle

Transportation is a fundamental requirement of modern life, but the traditional combustion engine is quickly becoming outdated. Petrol or diesel vehicles are highly polluting and are being quickly replaced by fully Electric Vehicles. Fully Electric Vehicles (EV) have zero tailpipe emissions and are much better for the environment. The Electric Vehicle revolution is here, and you can be part of it. Will your next vehicle be an electric one?

i. Lower running costs:

The running cost of an Electric Vehicle is much lower than an equivalent petrol or diesel vehicle. Electric Vehicles use electricity to charge their batteries instead of using fossil fuels like petrol or diesel. Electric Vehicles are more efficient, and that combined with the electricity cost means that charging an Electric Vehicle is cheaper than filling petrol or diesel for your travel requirements. Using renewable energy sources can make the use of Electric Vehicles eco-friendlier. The electricity cost can be reduced further if charging is done with the help of renewable energy sources installed at home, such as solar panels.

One litre of petrol produced 46KW energy in normal car, which runs 20 – 25km While in Electric vehicle 1 KW energy used to run 25- 30Km (approx.)

Fig.1.5: Lower running costs

ii. Low maintenance cost

Electric Vehicles have very low maintenance costs because they don't have as many moving parts as an internal combustion vehicle. The servicing requirements for Electric Vehicles are lesser than the conventional petrol or diesel vehicles. Therefore, the yearly cost of running an Electric Vehicle is significantly low.

1 litre Petrol = ₹ 100 to 110
While 1 kw electricity = ₹ 6 to 12

Fig.1.6: Electric vehicles have very low maintenance

iii. Zero Tailpipe Emissions

Driving an Electric Vehicle can help you reduce your Carbon footprint because there will be zero tailpipe emissions. You can reduce the environmental impact of charging your vehicle further by choosing renewable energy options for home electricity.

iv. Tax and financial benefits

Registration fees and road tax on purchasing Electric Vehicles are lesser than petrol or diesel vehicles. There are multiple policies and incentives offered by the government depending on which state you are in.

v. The use of petrol and diesel is destroying our planet

The availability of fossil fuels is limited, and their use is destroying our planet. Toxic emissions from petrol and diesel vehicles lead to long-term, adverse effects on public health. The emissions impact of Electric Vehicles is much lower than petrol or diesel vehicles. From an efficiency perspective, Electric Vehicles can convert around 60% of the electrical energy from the grid to power the wheels, but petrol or diesel cars can only convert 17%-21% of the energy stored in the fuel to the wheels. That is a waste of around 80%. Fully Electric Vehicles have zero tailpipe emissions, but even when electricity production is considered, petrol or diesel vehicles emit almost 3 times more Carbon Dioxide than the average EV. To reduce the impact of charging Electric Vehicles, India is ambitious to achieve about 40 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by the year 2030. Therefore, Electric Vehicles are the way forward for Indian transport, and we must switch to them now.

Fig.1.7: Air pollution by Internal Combustion Engines.

vi. Electric Vehicles are easy to drive and quiet

Electric Vehicles don't have gears and are very convenient to drive. There are no complicated controls, just accelerate, brake, and steer. When you want to charge your vehicle, just plug it in to a home or public charger. Also, Electric Vehicles are also quiet, so they reduce noise pollution that traditional vehicles contribute to.

vii. Convenience of charging at home

Imagine being at a busy fuel station during peak hours, and you are getting late to reach your workplace. These problems can easily be overcome with an Electric Vehicle. Simply plug in your vehicle at your home charger for 4-5 hours before you plan to go out. If you can get a charger where you park at home, it is very convenient to plan your journeys. What if you forget to plug in your machine someday? Then you can easily take the help of fast chargers or even battery swapping services if you are on a two-wheeler on the road.

Fig. 1.8: Charging at Home

viii. No noise pollution

Electric Vehicles have the silent functioning capability as there is no engine under the hood. No engine means no noise. The electric motor functions so

silently that you need to peek into your instrument panel to check if it is ON. Electric Vehicles are so silent that manufacturers have to add false sounds in order to make them safe for pedestrians.

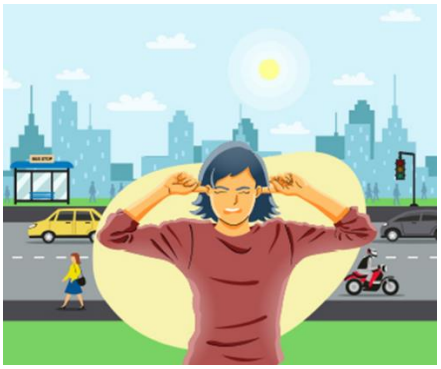


Fig.1.9: Pollution Free

Check Your Progress

A. Fill in the Blanks:

1. _____ is a reaction between the fuel and the air that releases heat and combustion products.
2. _____ are also quiet, so they reduce noise pollution that traditional vehicles contribute to.
3. The _____ impact of Electric Vehicles is much lower than petrol or diesel vehicles.
4. Unburned Hydro-Carbons are a result of the incomplete combustion of _____.

B. Multiple Choice Questions:

1. What is one of the financial benefits associated with purchasing an Electric Vehicle?

a) Higher registration fees
b) Lower road tax
c) Increased maintenance costs
d) Limited government incentives

2. What percentage of electrical energy from the grid can Electric Vehicles convert into power for the wheels?

a) 60%
b) 40%
c) 30%
d) 20%

3. Why are Electric Vehicles considered to be more environmental-friendlier compared to petrol or diesel vehicles?

a) They emit zero Carbon Dioxide during operation.
b) They produce less noise pollution on the roads.
c) They require fewer maintenance check-ups.
d) They have longer range capabilities.

4. What is a notable convenience of charging Electric Vehicles at home?

a) It requires specialised charging stations.
b) It takes a significantly longer time to charge.
c) It eliminates the need to visit fuel stations.
d) It increases the risk of electrical hazards.

5. Why do Electric Vehicles contribute to reducing noise pollution?

a) They have quieter engines.
b) They produce false sounds to mask their silence.
c) They operate at slower speeds.
d) They have soundproof cabins.

C. Short term

1. What are the environmental and human life problems caused by the large number of automobiles in use?
2. What are the toxic combustion products released by vehicles that harm human health?
3. Why are petrol or diesel vehicles being replaced by Electric Vehicles?
4. What are the benefits of Electric Vehicles in terms of running costs and maintenance?

Activity

1. Attend an Electric Vehicle Workshop to learn about the technology, how Electric Vehicles work, and their advantages.
2. Encourage students to research and make presentations about how the automotive industry affects the environment, especially in terms of air pollution, global warming, and the reduction of petroleum resources.

Session 3: Electric Vehicle Scenario in India

Government policies to promote Electric Vehicles

In recent years, the manufacturing of Electric Vehicles (EVs) has gone up significantly in the Indian market. To minimise pollution and its overdependence on fossil fuels, the Indian government has actively promoted the use of Electric Vehicles. To promote EV manufacturing and adoption in the nation, numerous programmes and policy changes have been put in place.

In response to concerns over climate change and the reduction of greenhouse gas emissions, many countries are shifting to Electric Vehicles. India is no exception. In 2010, the Indian government announced the National Electric Mobility Mission Plan, which aimed to provide a comprehensive framework for the promotion and adoption of Electric Vehicles in India. This was followed by the launch of the ***Faster Adoption and Manufacturing of Electric Vehicles (FAME)*** scheme in 2015 (as shown in Fig. 1.10). The FAME programme aims to promote the use of EVs in public transportation and to create a robust charging infrastructure across the country. This scheme also aimed at providing incentives to encourage the production and use of Electric Vehicles in India.

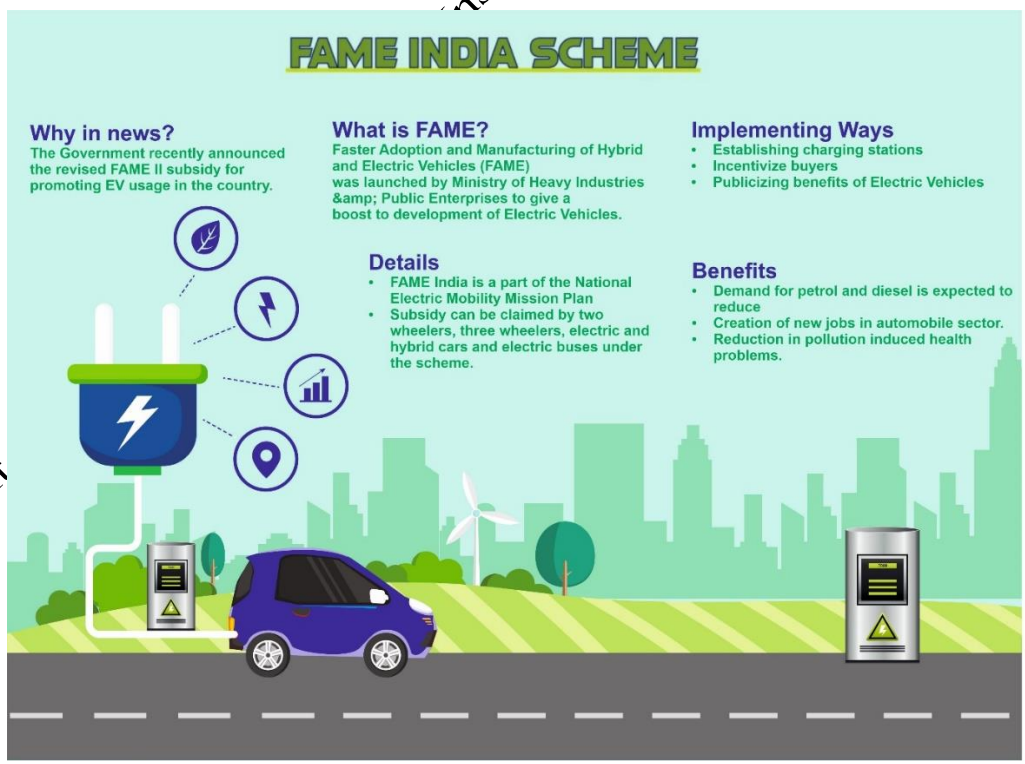


Fig.1.10: FAME SCHEME

One of the major challenges facing the EV industry in India is the lack of charging infrastructure. To address this challenge, the government has set a target of establishing 1.32 million public charging stations across the country by 2030 (**source:** CII report, July 2023). In addition, the government has also announced plans to build charging stations at all petrol pumps across the country.

Another challenge facing the EV industry in India is the high cost of EVs. While the cost of EVs has come down in recent years, they are still more expensive than traditional gasoline-powered vehicles. To address this challenge, the government has introduced various incentives to promote the adoption of EVs. These incentives include a reduction in GST (Goods and Services Tax) rates, income tax deductions for EV owners, and subsidies for EV manufacturers.

The Indian government has also taken steps to promote the use of EVs in public transportation. In 2018, the government announced plans to convert all government-owned vehicles to electric by 2030. In addition, the government has also launched several pilot projects to test the viability of EVs in public transportation. These pilot projects include the deployment of electric buses in various cities across the country.

The adoption of EVs in India is not without its challenges. In addition to the lack of charging infrastructure and high cost, there are also concerns over the reliability and durability of EV batteries in India's harsh climate. However, with the government's support and the growing demand for sustainable transportation solutions, the EV industry in India is poised for growth.

Here are some important details about the production of Electric Vehicles in the Indian market:

FAME II Scheme: The Indian government's flagship programme, the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme, aims to encourage the production of electric and hybrid vehicles in the nation. Launched in 2019, FAME II offers incentives to EV manufacturers, including financial assistance for EV buyers and assistance with the expansion of the infrastructure for charging EVs.

Benefits and Incentives: The government offers Electric Vehicle manufacturers a number of advantages and incentives. These include lower import duties on EV components, lower GST (Goods and Services Tax) rates

on EVs compared to conventional vehicles, and income tax advantages for EV manufacturing companies.

Charging Infrastructure: For the widespread adoption of Electric Vehicles, a reliable charging infrastructure must be developed. Programmes have been started by the government to create a nationwide network of charging stations. It supports the installation of charging stations by encouraging both public and private organisations to do so.

Automotive Policy: To speed up the adoption of Electric Vehicles, the Indian government is developing a new automotive policy. The policy is expected to include steps to support EV production and homemade component manufacturing.

Local Manufacturing and Production: Several domestic and foreign automakers have expressed interest in establishing factories in India for the production of Electric Vehicles. For the manufacture of Electric Vehicles, businesses like Tata Motors, Mahindra and Mahindra, and Hero Electric have already built factories. Additionally, electric models have been released in the Indian market by foreign automakers including Hyundai, MG Motor, and Kia Motors.

Production of Batteries: India has observed an increase in the production of batteries, a huge component of Electric Vehicles. Through incentives and collaborations with battery manufacturers, the government has started to promote domestic battery manufacturing. This is expected to lower the price of Electric Vehicles and increase their marketability.

Targets for EV Adoption: The Indian government has set high goals for the uptake of Electric Vehicles in the nation. 30 percent of private and commercial vehicles should be electric by 2030, according to the National Electric Mobility Mission Plan.

Check Your Progress

A. Fill in the Blanks:

1. The FAME programme aims to promote the use of _____ in public transportation.
2. The Faster Adoption and Manufacturing of Electric Vehicles (FAME) was launched in the year_____.

B. Multiple Choice Questions:

1. What is the main objective of the National Electric Mobility Mission Plan in India?
   a) To reduce pollution and dependence on fossil fuels
   b) To promote public transportation
   c) To increase the production of traditional gasoline-powered vehicles
   d) To establish a nationwide network of charging stations

2. When was the FAME II scheme launched in India?

   a) 2010
   b) 2015
   c) 2018
   d) 2019

3. What is one of the major challenges faced by the EV industry in India?

   a) Lack of charging infrastructure
   b) High taxes on EV components
   c) Low demand for Electric Vehicles
   d) Insufficient financial assistance for EV buyers

4. How is the Indian government addressing the high cost of Electric Vehicles?

   a) Offering income tax advantages for EV manufacturing companies
   b) Reducing GST rates on EVs compared to conventional vehicles
   c) Imposing higher taxes on EV owners
   d) Discouraging the production of EVs

5. What is the purpose of the FAME II scheme in India?

   a) To promote public transportation
   b) To reduce pollution from battery production
   c) To encourage the production of electric and hybrid vehicles
   d) To increase import duties on EV components

6. What is the purpose of the upcoming automotive policy in India?
   a) To promote the production of traditional gasoline-powered vehicles
   b) To reduce the import duties on EV components
   c) To support EV production, and homemade component manufacturing
   d) To increase the GST rates on conventional vehicles

C. Short term

1. What are the main objectives of the FAME II scheme in India?
2. What are the concerns regarding the reliability and durability of EV batteries in India's harsh climate?
3. Which domestic and foreign automakers have established factories in India for the production of Electric Vehicles?

Activity

1. Find the charging infrastructure in your city and find the type of charger they used.
2. Collect the images from newspaper and magazine of Electric Vehicle launched in current year.

Session 4: Role and Duties of EV Service Assistant

An Electric Vehicle Service Assistant is a professional who provides support and assistance to customers who own or use Electric Vehicles. Their main responsibility is to ensure that Electric Vehicle users have a smooth and hassle-free experience with their vehicles. Their duties may include providing customer service, doing maintenance and repairs on Electric Vehicles, installing and maintaining charging infrastructure and keeping records of all maintenance and repairs performed on Electric Vehicles. An Electric Vehicle Service Assistant is an important role in the Electric Vehicle industry, as they help to ensure that customers have a positive experience with their Electric Vehicles.

Fig.1.11: Duties of EV Service Assistant

The duties of an EV Service Assistant may vary depending on the specific job and employer, but generally include the following:

1. **Customer service**: An EV Service Assistant must provide excellent customer service to Electric Vehicle users. This may involve answering questions about the vehicle, providing technical support, and addressing any concerns or issues that customers may have.
2. **Vehicle maintenance:** An EV Service Assistant may be responsible for performing routine maintenance on Electric Vehicles, such as checking the battery, inspecting the tires, and testing the electrical system.
3. **Repairs:** In the event of a breakdown or malfunction, an EV Service Assistant may need to diagnose and repair the vehicle. This may involve replacing parts, troubleshooting electrical issues, and performing other repairs as needed.
4. **Charging infrastructure:** An EV Service Assistant may be responsible for installing and maintaining charging stations for Electric Vehicles. This includes ensuring that the charging stations are functioning properly and addressing any issues that arise.
5. **Documentation:** An EV Service Assistant must maintain accurate records of all maintenance and repairs performed on Electric Vehicles. This may include documenting the type of service performed, the parts used, and the cost of the service.

The role of an EV Service Assistant is critical in ensuring that Electric Vehicle users have a positive experience and can enjoy the benefits of driving an Electric Vehicle with confidence. They must be knowledgeable about the vehicle and charging infrastructure, have excellent communication skills, and be able to provide top-notch customer service to Electric Vehicle users.

JOB OPPORTUNITIES

As the use of Electric Vehicles continues to grow, the demand for EV Service Assistants is also increasing. There are various job opportunities available for EV Service Assistants in different sectors, including:

1. **Automotive Dealerships**: Many car dealerships now offer Electric Vehicles and require EV Service Assistants to support customers with maintenance, repairs, and other EV-related services.
2. **EV Charging Companies**: As the number of Electric Vehicles on the road increases, the demand for charging infrastructure also grows. EV charging companies hire EV Service Assistants to install, maintain and repair charging stations for Electric Vehicles.

3. **Electric Vehicle Manufacturers**: Electric vehicle manufacturers may hire EV service assistants to provide technical support, perform maintenance and repairs, and assist with the installation and testing of new electric vehicle models.
4. **Fleet Management Companies**: Companies that operate fleets of Electric Vehicles, such as delivery or transportation companies, need EV Service Assistants to keep their vehicles in good working condition and ensure that their operations run smoothly.
5. **Independent Repair Shops:** Some independent repair shops specialize in Electric Vehicles and need EV Service Assistants to provide maintenance and repair services to their customers.

The job opportunities for EV Service Assistants are diverse and growing. The skills and knowledge required for this role are in high demand, and there are many exciting opportunities available for individuals interested in pursuing a career in the Electric Vehicle industry.

Check Your Progress

Multiple Choice Questions:

1. What is the main responsibility of an Electric Vehicle Service Assistant?
a) Selling Electric Vehicles to customers
b) Providing support and assistance to Electric Vehicle users
c) Designing charging infrastructure for Electric Vehicles
d) Researching on Electric Vehicle technology

2. Which of the following is a duty of an EV Service Assistant?
a) Marketing Electric Vehicles to potential customers
b) Developing new battery technology for Electric Vehicles
c) Installing and maintaining charging stations for Electric Vehicles
d) Designing the exterior features of Electric Vehicles

3. What does an EV Service Assistant do in terms of customer service?
a) Process sales transactions for Electric Vehicles
b) Provides technical support to Electric Vehicle owners
c) Offers insurance coverage for Electric Vehicles
d) Conducts market research on Electric Vehicle trends

4. What is a responsibility of an EV Service Assistant regarding vehicle maintenance?
a) Managing the inventory of Electric Vehicle parts

b) Conducting safety inspections for traditional vehicles
c) Monitoring the fuel consumption of Electric Vehicles
d) Performing routine maintenance on Electric Vehicles

Short term

What are the main responsibilities of an Electric Vehicle Service Assistant?
What is the importance of customer service for an EV Service Assistant?
What types of maintenance tasks might an EV Service Assistant perform on Electric Vehicles?
What are the key duties of an EV Service Assistant when it comes to repairs?

Activity

1. Create a presentation or poster about the job opportunities available for Electric Vehicle Service Assistants.
2. Visit an Electric Vehicle service centre or invite professionals who work as Electric Vehicle Service Assistants.

Module 2:	Electric Vehicles and Their Components

Module Overview

The modern era of transportation has witnessed a significant transformation with the introduction of various types of Electric Vehicles (EVs). These EVs have emerged as eco-friendly alternatives to traditional internal combustion engine vehicles, promising reduced emissions and enhanced energy efficiency. In this Module, we will explore several key categories of Electric Vehicles available on the market today, each offering a unique blend of advantages and disadvantages.

Learning Outcome

After completing this module, you will be able to:

- Identify and describe the different types of Electric Vehicles (EVs), including Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles (PHEVs), and Hybrid Electric Vehicles (HEVs).
- Understand the function and importance of each component in the overall operation of an EV.
- Identify the different types of batteries used in EVs and their respective advantages and disadvantages.
- Compare and contrast the fundamental differences between conventional internal combustion engine vehicles and electric vehicles.

Module Structure

Session 1: Types of Electric Vehicles
Session 2: Components of Electric Vehicles
Session 3: Differentiate Between Conventional Vehicles and Electric Vehicles

Session 1: Types of Electric Vehicles

There are several types of Electric Vehicles (EVs) available on the market today, including:

1) Battery Electric Vehicles (BEVs)
2) Hybrid Electric Vehicles (HEVs)
3) Plug-in Hybrid Electric Vehicles (PHEVs)

4) Fuel Cell Electric Vehicles (FCEVs)
5) Neighbourhood Electric Vehicles (NEVs)
6) Electric Bikes and Scooters

Each type of Electric Vehicle has its advantages and disadvantages, and the choice of which type to use will depend on factors such as range, cost, and intended use.

1) **Battery Electric Vehicles (BEVs)**: BEVs are also known as All-Electric Vehicles (AEV). Electric Vehicles using BEV technology run entirely on a battery-powered electric drivetrain. The electricity used to drive the vehicle is stored in a large battery pack which can be charged by plugging into the electricity grid. The charged battery pack then provides power to one or more electric motors to run the electric car. The flow diagram of Battery Electric Vehicle as shown in Fig. 2.1.

Main Components of BEV:
Electric motor, Inverter, Battery, Control Module, Drive train. The components of Battery Electric Vehicle as shown in Fig. 2.2.

Working Principles of BEV:
The power for the electric motor is converted from the DC Battery to AC. As the accelerator is pressed, a signal is sent to the controller. The controller adjusts the speed of the vehicle by changing the frequency of the AC power from the inverter to the motor. The motor then connects and leads to the turning of wheels through a cog. If the brakes are pressed, or the electric car is decelerating, the motor becomes an alternator and produces power, which is sent back to the battery

Examples of BEV:
MG ZS, TATA Nexon, TATA Tigor, Mahindra E20 plus, Hyundai Kona, Mahindra Verito

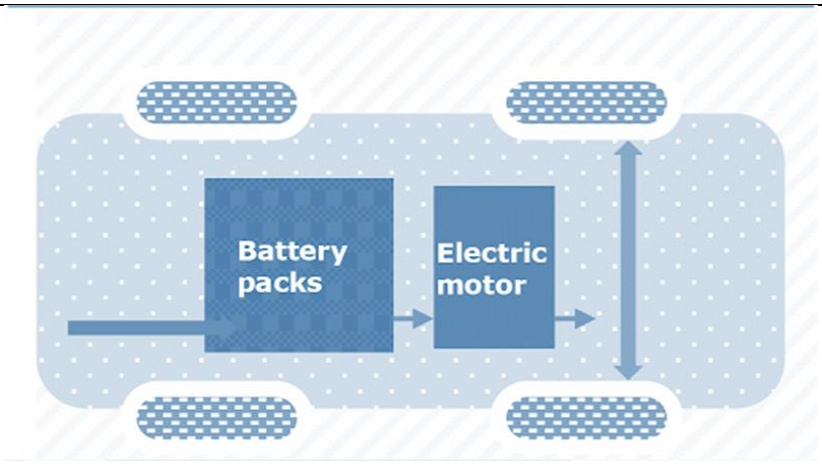


Fig. 2.1: Flow Diagram of Battery Electric Vehicles (BEVs)

BEVs must be plugged in to an external power source in order to recharge their battery pack. This can be done using a standard electrical outlet, a dedicated charging station, or a fast-charging station. The charging time for a BEV can vary depending on the battery size and charging speed, but can typically range from a few hours to several hours.

Advantages of BEVs

- **Zero Emissions:** BEVs do not produce any tailpipe emissions, which means they are much cleaner and more environmentally friendly than traditional gasoline-powered vehicles. This is particularly important in cities, where air pollution is a major health concern.
- **Lower Operating Costs:** BEVs have lower operating costs than gasoline-powered vehicles, as the cost of electricity is typically lower than the cost of gasoline. In addition, BEVs require less maintenance than traditional vehicles, as they have fewer moving parts and do not require oil changes.
- **Quiet and Smooth Driving Experience:** BEVs are very quiet and provide a smooth driving experience due to the lack of an internal combustion engine. This can be particularly enjoyable for drivers and passengers, as well as reducing noise pollution in urban areas.
- **Energy Security**: BEVs provide a level of energy security, as they can be powered by renewable energy sources such as solar or wind power. This reduces dependence on fossil fuels, which are subject to price fluctuations and geopolitical risks.

Limitation of BEVs

- **Limited Range**: The range of a BEV is typically shorter than that of a traditional gasoline-powered vehicle. This means that BEVs may not be

suitable for long-distance driving, and drivers may need to plan their routes carefully to ensure they have access to charging infrastructure.

- **Charging Time:** The time required to charge a BEV can be longer than the time required to refuel a gasoline-powered vehicle. This means that drivers may need to plan their charging stops carefully and may need to wait for their vehicles to charge before continuing their journey.
- **Charging Infrastructure**: To recharge a BEV, drivers need access to charging infrastructure, such as public charging stations or dedicated home charging stations. The availability of charging infrastructure can vary depending on the location, which may limit the ability of drivers to use BEVs in some areas.
- **Upfront Cost**: The upfront cost of a BEV can be higher than the cost of a traditional gasoline-powered vehicle. This is due to the cost of the battery pack, which is the most expensive component of the vehicle. However, as battery technology continues to improve and production volumes increase, the cost of BEVs is expected to decline.

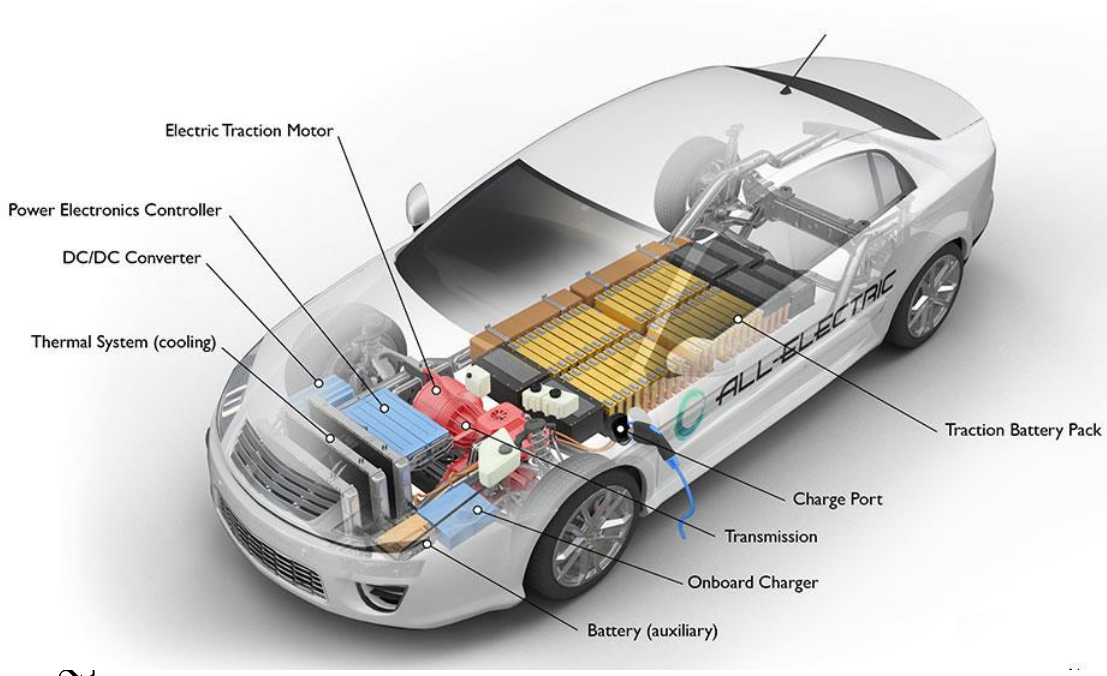


Fig. 2.2: Components of Battery Electric Vehicles (BEVs)

Key Components of an All-Electric Car

i. Battery (all-electric auxiliary): In an electric drive vehicle, the auxiliary battery provides electricity to power vehicle accessories.
ii. Traction battery pack: Stores electricity for use by the electric traction motor.
iii. Transmission (electric) / powertrain: The transmission transfers mechanical power from the electric traction motor to drive the wheels.

iv. Electric traction motor: Using power from the traction battery pack, this motor drives the vehicle's wheels. Some vehicles use motor generators that perform both the drive and regeneration functions.

v. Traction Motor controller: This unit manages the flow of electrical energy delivered by the traction battery, controlling the speed of the electric traction motor and the torque it produces

vi. Charge port: The charge port allows the vehicle to connect to an external power supply in order to charge the traction battery pack.

vii. DC/DC converter: This device converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.

viii. Onboard charger: Takes the incoming AC electricity supplied via the charge port and converts it to DC power for charging the traction battery. It also communicates with the charging equipment and monitors battery characteristics such as voltage, current, temperature, and state of charge while charging the pack.

ix. Thermal system (cooling): This system maintains a proper operating temperature range of the engine, electric motor, power electronics, and other components.

2. **Hybrid Electric Vehicles** (HEVs): HEVs are also known as series hybrid or parallel hybrid. HEVs have both engine and electric motor. The engine gets energy from fuel, and the motor gets electricity from batteries. The transmission is rotated simultaneously by both engine and electric motor. This then drives the wheels. The flow diagram of Hybrid Electric Vehicle as shown in Fig. 2.3.

Main Components of HEV (as shown in Fig. 2.4)**:**
Engine, Electric motor, Battery pack with controller and inverter, Fuel tank, Control module

Working Principles of HEV:
The fuel tank supplies energy to the engine like a regular car. The batteries run on an electric motor. Both the engine and electric motor can turn the transmission at the same time.

Examples of HEV:
Engine, Electric motor, Battery pack with controller and inverter, Fuel tank, Control module

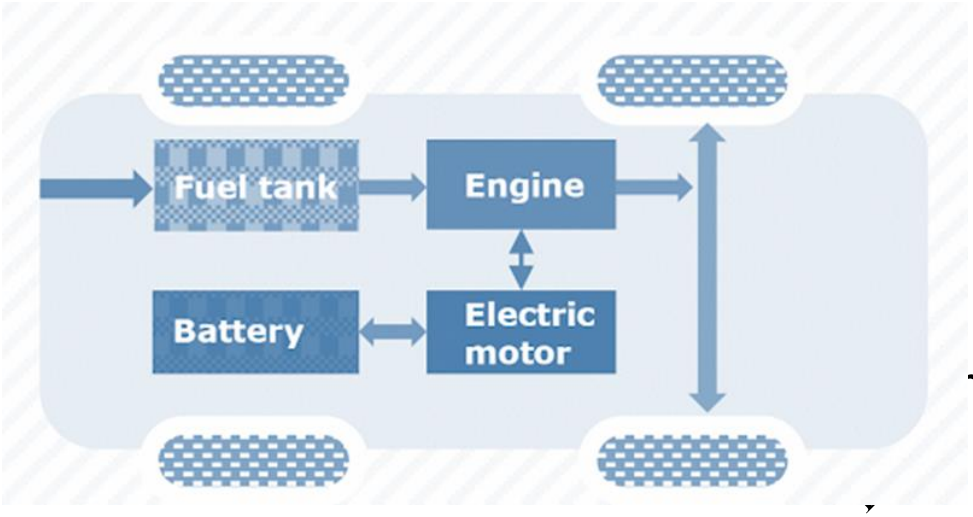


Fig. 2.3: Flow Diagram of Hybrid Electric Vehicles

HEVs come in several configurations, but the parallel hybrid is the most common type. In a parallel hybrid, both the gasoline engine and the electric motor are connected to the transmission and can power the wheels. Depending on driving conditions, the engine and motor can work together or independently.

Advantages of HEVs:

- They can achieve significantly better fuel economy than traditional gasoline-powered vehicles. This is because the electric motor provides additional power to the engine, reducing the need for the engine to work as hard.
- HEVs can also use regenerative braking to capture energy that is normally lost during braking, which can be used to power the electric motor.
- They produce fewer emissions than traditional gasoline-powered vehicles. The electric motor provides additional power to the engine, which reduces the amount of fuel that is needed to power the vehicle. This in turn reduces the amount of emissions that are produced.

Disadvantages of HEV

One of the challenges of HEVs is that they are more complex than traditional gasoline-powered vehicles. They require a larger battery, an electric motor, and a sophisticated control system to manage the interaction between the engine and the motor. This can make them more expensive to produce and maintain than traditional vehicles.

Another challenge of HEVs is that they require a specialized infrastructure for charging and maintenance. While HEVs can recharge their batteries using regenerative braking, they may also require an external power source to fully recharge the battery. This means that charging stations and other infrastructure may need to be installed to support HEVs.

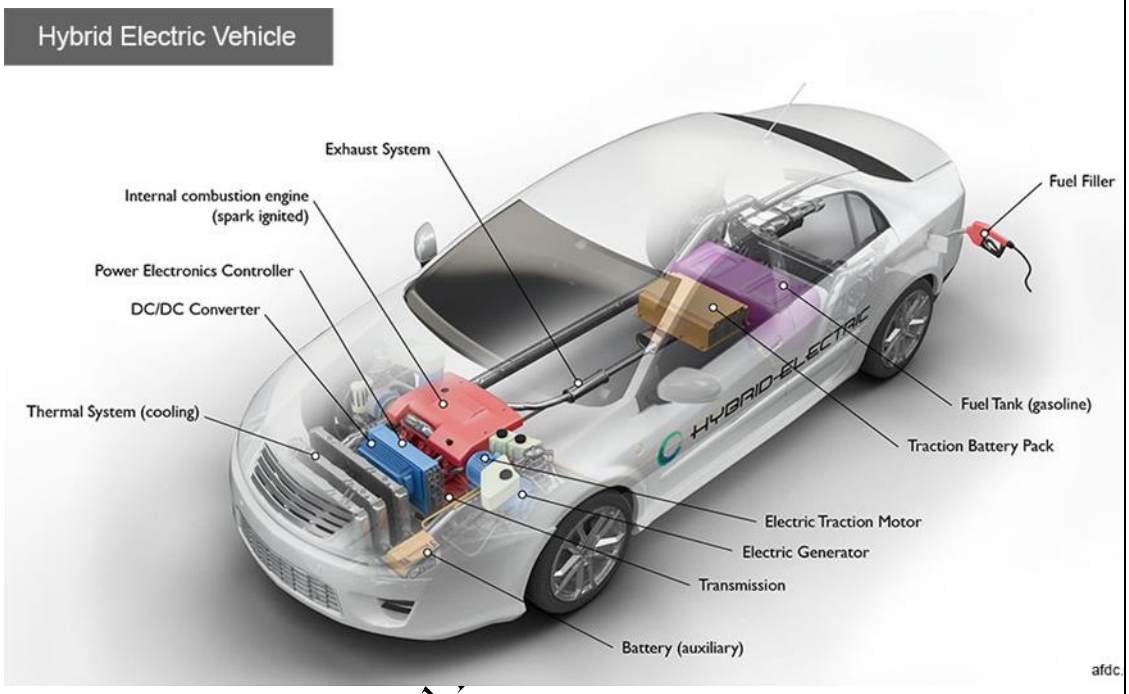


Fig. 2.4: Components of Hybrid Electric Vehicles

Key Components of a Hybrid Electric Car

- Battery (auxiliary): In an electric vehicle, the low-voltage auxiliary battery starts the car before the traction battery is engaged and powers vehicle accessories.
- DC/DC converter: This device converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.
- Electric generator: Generates electricity from the rotating wheels while braking, transferring that energy to the traction battery pack. Some vehicles use motor generators that perform both the drive and regeneration functions.
- Electric traction motor: Using power from the traction battery pack, this motor drives the vehicle's wheels. Some vehicles use motor generators that perform both the drive and regeneration functions.

- Exhaust system: The exhaust system channels the exhaust gases from the engine out through the tailpipe. A three-way catalyst is designed to reduce engine-out emissions within the exhaust system.
- Fuel filler: A nozzle from a fuel dispenser attaches to the receptacle on the vehicle to fill the tank.
- Fuel tank (gasoline): This tank stores gasoline on board the vehicle until it's needed by the engine.
- Internal combustion engine (spark-ignited): In this configuration, fuel is injected into either the intake manifold or the combustion chamber, where it is combined with air, and the air/fuel mixture is ignited by the spark from a spark plug.
- Power electronics controller: This unit manages the flow of electrical energy delivered by the traction battery, controlling the speed of the electric traction motor and the torque it produces.
- Thermal system (cooling): This system maintains a proper operating temperature range of the engine, electric motor, power electronics, and other components.
- Traction battery pack: Stores electricity for use by the electric traction motor.
- Transmission: The transmission transfers mechanical power from the engine and/or electric traction motor to drive the wheels.

3. **Plug-in Hybrid Electric Vehicles (PHEVs):** The PHEVs are also known as series hybrids. They have both engine and a motor. You can choose among the fuels, conventional fuel (such as petrol) or alternative fuel (such as bio-diesel). It can also be powered by a rechargeable battery pack. The battery can be charged externally. The flow diagram of 3. Plug-in Hybrid Electric Vehicle as shown in Fig. 2.5.

PHEVs can run in at least 2 modes:

- All-electric Mode, in which the motor and battery provide all the car's energy
- Hybrid Mode, in which both electricity and petrol/diesel are employed

Main Components of PHEV:

Electric motor, Engine, Inverter, Battery, Fuel tank, Control module, Battery Charger (if onboard model)

Working Principles of PHEV:

PHEVs start-up in all-electric mode and make use of electricity until their battery pack is depleted. Once the battery gets drained, the engine takes over, and the vehicle operates as a conventional, non-plug-in hybrid. PHEVs can be charged by plugging into an outside electric power source, engine, or regenerative braking. When brakes are applied, the electric motor acts as a generator, using the energy to charge the battery. The engine's power is supplemented by the electric motor; as a result, smaller engines can be used, increasing the car's fuel efficiency without compromising performance.

Examples of PHEV:

Porsche Cayenne S E-Hybrid, BMW 330e, Porsche Panamera S E-hybrid, Chevy Volt, Chrysler Pacifica, Ford C-Max Energi, Mercedes C350e, Mercedes S550e, Mercedes GLE550e, Mini Cooper SE Countryman, Ford Fusion Energi, Audi A3 E-Tron, BMW i8, BMW X5 xdrive40e, Fiat 500e, Hyundai Sonata, Kia Optima, Volvo XC90 T8.

PHEVs have two power sources: an electric motor and a gasoline engine. The electric motor is powered by a rechargeable battery that can be plugged into an external power source to charge. The gasoline engine is used to power the car when the battery is depleted or when the driver needs to travel longer distances than the electric motor alone can provide. The gasoline engine also helps to recharge the battery while driving, which extends the vehicle's electric range.

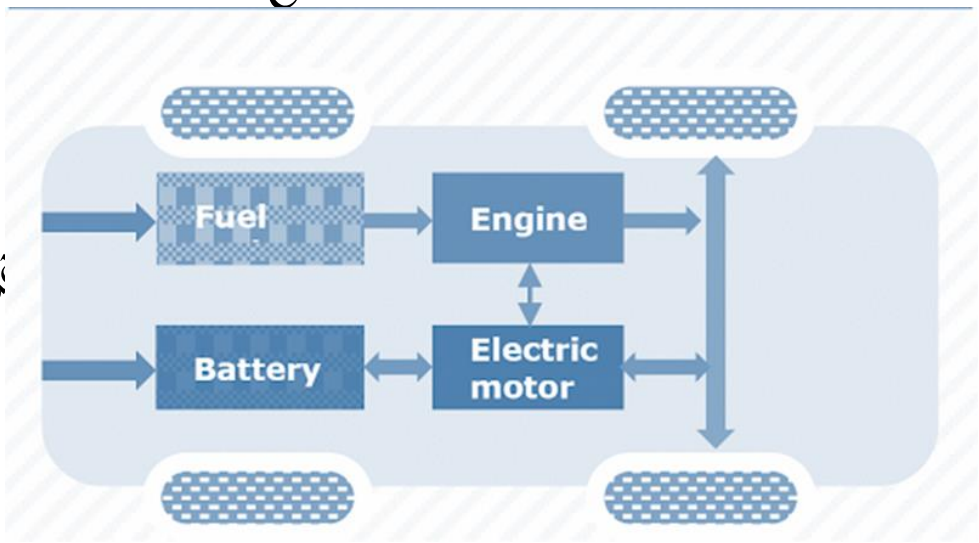


Fig. 2.5: Flow Diagram of Plug-in Hybrid Electric Vehicles

PHEVs offer several advantages over traditional gasoline-powered vehicles: -

- Lower emissions than traditional vehicles, as the electric motor produces no emissions and the gasoline engine is used less frequently.
- PHEVs can achieve better fuel economy than traditional gasoline-powered vehicles, especially in urban driving conditions where the electric motor can be used exclusively.
- PHEVs can offer the convenience of gasoline-powered vehicles for longer trips while still providing the benefits of electric power for shorter trips.
- PHEVs has the ability to charge the battery from an external power source. This can be done at home, using a standard wall outlet or at a public charging station.

There are two types of PHEVs: series and parallel.

I. In a series PHEV, the gasoline engine is used only to charge the battery, which then powers the electric motor.

II. In a parallel PHEV, both the gasoline engine and the electric motor can power the vehicle independently or together.

*Most PHEVs on the market today are parallel hybrids, as they offer more flexibility in how the vehicle is powered.

In terms of cost, PHEVs are generally more expensive than traditional gasoline-powered vehicles but less expensive than BEVs. PHEVs also offer potential cost savings over time, as they require less fuel than traditional vehicles and can take advantage of lower electricity rates during off-peak hours. Some PHEVs also qualify for federal and state tax credits and rebates, which can help to offset the upfront cost of the vehicle.

The components of plug in Hybrid Electric Vehicle as shown in Fig. 2.6.

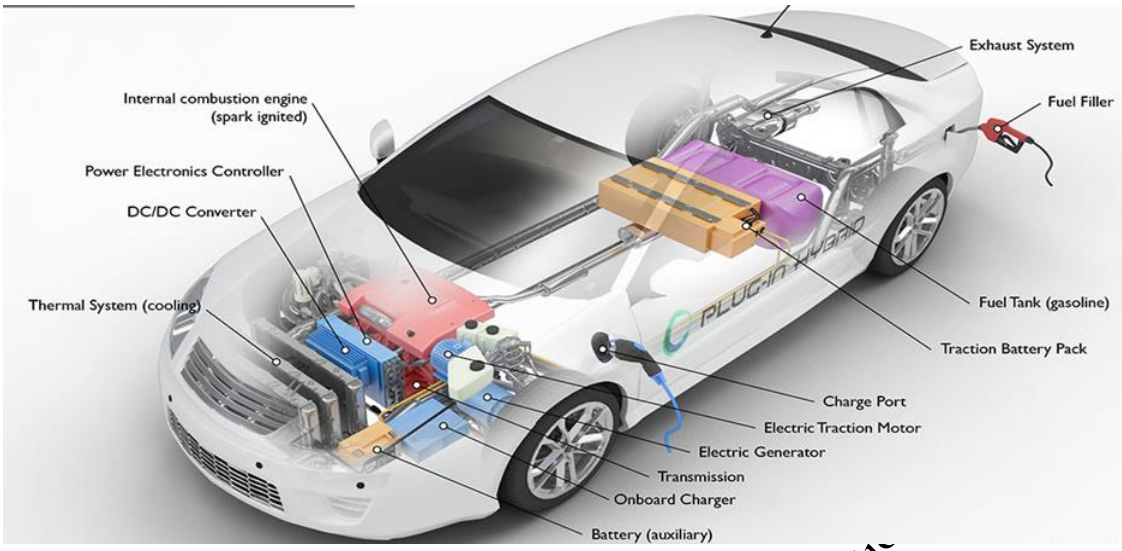


FIG. 2.6: Components of Plug-in Hybrid Electric Vehicles

Key Components of a Plug-In Hybrid Electric Car

- Battery (auxiliary): In an electric drive vehicle, the low-voltage auxiliary battery provides electricity to start the car before the traction battery is engaged; it also powers vehicle accessories.
- Charge port: The charge port allows the vehicle to connect to an external power supply to charge the traction battery pack.
- DC/DC converter: This device converts higher-voltage DC power from the traction battery pack to the lower-voltage DC power needed to run vehicle accessories and recharge the auxiliary battery.
- Electric generator: Generates electricity from the rotating wheels while braking, transferring that energy back to the traction battery pack. Some vehicles use motor generators that perform both the drive and regeneration functions.
- Electric traction motor: Using power from the traction battery pack, this motor drives the vehicle's wheels. Some vehicles use motor generators that perform both the drive and regeneration functions.
- Exhaust system: The exhaust system channels the exhaust gases from the engine out through the tailpipe. A three-way catalyst is designed to reduce engine-out emissions within the exhaust system.
- Fuel filler: A nozzle from a fuel dispenser attaches to the receptacle on the vehicle to fill the tank.
- Fuel tank (gasoline): This tank stores gasoline on board the vehicle until it's needed by the engine.
- Internal combustion engine (spark-ignited): In this configuration, fuel is injected into either the intake manifold or the combustion chamber,

where it is combined with air, and the air/fuel mixture is ignited by the spark from a spark plug.

- Onboard charger: Takes the incoming AC electricity supplied via the charge port and converts it to DC power for charging the traction battery. It also communicates with the charging equipment and monitors battery characteristics such as voltage, current, temperature, and state of charge while charging the pack.
- Power electronics controller: This unit manages the flow of electrical energy delivered by the traction battery, controlling the speed of the electric traction motor and the torque it produces.
- Thermal system (cooling): This system maintains a proper operating temperature range of the engine, electric motor, power electronics, and other components.
- Traction battery pack: Stores electricity for use by the electric traction motor.
- Transmission: The transmission transfers mechanical power from the engine and/or electric traction motor to drive the wheels.

4. **Fuel Cell Electric Vehicles (FCEVs):** FCEVs use hydrogen and oxygen to produce electricity, which powers an electric motor. They emit only water vapour and do not require any charging, as they produce their electricity through a chemical reaction. The flow diagram of Fuel Cell Electric Vehicle as shown in Fig. 2.7.

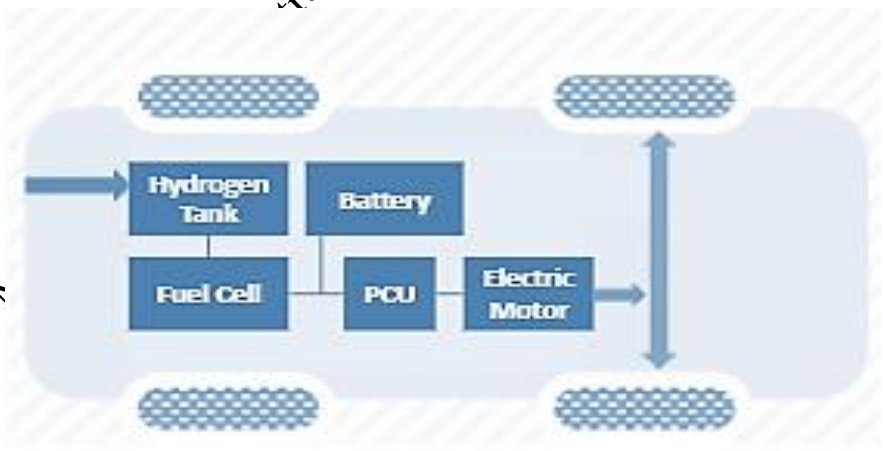


Fig. 2.7: Flow Diagram of Fuel Cell Electric Vehicles (FCEVs)

5. **Neighbourhood Electric Vehicles (NEVs):** NEVs are small Electric Vehicles that are designed for short trips in urban areas. They are limited to a top speed of 25 Kmph and are typically used for low-speed transportation in gated communities, resorts, and college campuses.

6. **Electric bikes and scooters** are becoming increasingly popular as a mode of urban transportation as shown in Fig 2.8. They are powered by an electric motor and have a speed range of up to 70-110 kmph on a single charge.

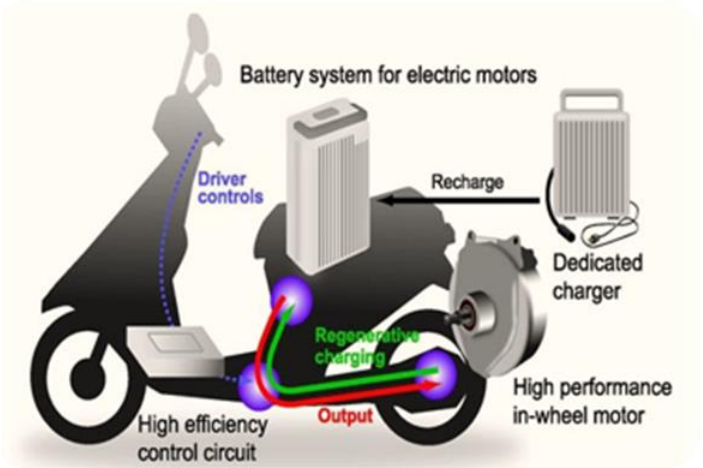


Fig. 2.8: Electric Bikes and Scooters

This table should provide a basic comparison of BEV, HEV, and PHEV vehicles. It's important to note that the specific details may vary depending on the make and model of the vehicle, but this gives a general overview of their key differences.

Table 1: Comparison between Battery Electric Vehicle (BEV), Hybrid Electric Vehicles (HEV), and Plug-in Hybrid Electric Vehicles (PHEV)

Feature	BEV (Battery Electric Vehicle)	HEV (Hybrid Electric Vehicle)	PHEV (Plug-in Hybrid Electric Vehicle)
Power Source	Electric motor powered by a battery	Combustion engine and electric motor	Combustion engine and electric motor

Fuel	Electricity	Gasoline or Diesel	Gasoline or Diesel and Electricity
Charging	Requires plug-in charging	Self-charging through regenerative braking and engine power	Requires plug-in charging, can also self-charge
Range	Limited by battery capacity	Unlimited (in most cases)	Limited by battery capacity and gasoline
Emissions	Zero tailpipe emissions	Produces emissions	Lower emissions compared to traditional vehicles
Fuel Efficiency	High (measured in miles per kWh)	Good (measured in miles per gallon)	Varies, depends on driving habits
Maintenance	Fewer moving parts, lower maintenance costs	Regular maintenance required	Regular maintenance required
Environmental Impact	Lower carbon footprint when charged with clean energy	Moderate environmental impact	Lower environmental impact compared to traditional vehicles
Cost	Initial cost can be higher	Moderate initial cost	Moderate initial cost

Check Your Progress

A. Fill in the Blanks:

1. _____ run entirely on electric power stored in a battery, with no internal combustion engine.
2. _____ have both an electric motor and an internal combustion engine.
3. _____ have an internal combustion engine and an electric motor, but the electric motor is used to assist the engine, rather than being the primary source of power.

4. _____ use hydrogen and oxygen to produce electricity, which powers an electric motor.

5. _____ are small Electric Vehicles that are designed for short trips in urban areas.

B. Multiple Choice Questions:

1.What type of Electric Vehicle runs entirely on electric power stored in a battery?
a) Plug-in Hybrid Electric Vehicle (PHEV)
b) Hybrid Electric Vehicle (HEV)
c) Battery Electric Vehicle (BEV)
d) Fuel Cell Electric Vehicle (FCEV)

2. What is the main advantage of BEVs over traditional gasoline-powered vehicles?
a) Lower operating costs
b) Longer range
c) Zero tailpipe emissions
d) Faster charging time

3. What is one disadvantage of BEVs compared to traditional vehicles?
a) Limited range
b) Slower acceleration
c) Higher maintenance costs
d) Higher fuel consumption

4. How do PHEVs recharge their battery packs?
a) By using regenerative braking
b) By using a fuel cell
c) By plugging into an external power source
d) By using solar panels

5. What technology allows HEVs to capture and store energy normally lost during braking?
a) Regenerative braking
b) Stop-start system
c) Electric traction motor
d) Charging infrastructure

C. Short term

1. What is regenerative braking and how does it contribute to the efficiency of HEVs?
2. What challenges do HEVs face in terms of complexity and infrastructure requirements?
3. How do HEVs contribute to reducing the Carbon footprint of the transportation sector?
4. How do the advantages and disadvantages of HEVs compare to those of BEVs and PHEVs?
5. What are the key components of a hybrid electric car and how do they function?

Activity

1. Classify the Electric Vehicles which are used, depending upon factors such as range, cost and intended use.

S.	Name of Electric Vehicle	Features of Electric Vehicle

Session 2: Components of Electric Vehicles

When you drive an EV, you start by pressing a button or using a key fob, much like a regular automobile. Instead of using the key to start the engine, you merely press a button to activate the electric motor. The electric motor is attached to the wheels of the vehicle and converts electrical energy from the battery into mechanical energy to push the vehicle forward. When you apply the brakes in an electric car, the electric motor converts from using energy to propel the vehicle forward to working as a generator, producing power that is then stored in the battery pack. The operation of an EV is based on the use of electricity stored in a rechargeable battery to power an electric motor, which moves the vehicle's wheels. This produces a clean, efficient and environmentally beneficial means of transportation with the potential to dramatically reduce our reliance on fossil fuels.

Important components of Electric Vehicle areas

1) Battery Pack
2) Electric Motor
3) Motor Controller
4) Electric powertrain
5) On Board Charger
6) DC - DC Convertor
7) Electric Vehicle Inverter
8) Battery Management System: Thermal /Regenerative
9) Vehicle Control Unit
10) Wiring Harness
11) Charging Port

1. Battery Pack

The battery pack is the heart of an Electric Vehicle. It stores electrical energy that is used to power the electric motor. These batteries are lightweight and offer content high power, making them ideal for use in Electric Vehicles. The battery pack is typically made up of a large number of individual battery cells that are connected in series and/or parallel to achieve the desired voltage and capacity.

The type and size of the battery pack (as shown in fig. 2.9) used in an Electric Vehicle can have a significant impact on the vehicle's performance, range, and overall cost. Electric Vehicles (EVs) use different types of batteries to store and provide the electrical energy needed to power the vehicle. The most common types of batteries used in Electric Vehicles are:

a) Lithium-Ion (Li-ion) Batteries: These are the most common batteries in electric cars. They work a lot like the batteries in your gadgets but are bigger and more powerful. They can store a lot of energy and are great for driving longer distances.
b) Nickel-Metal Hydride (NiMH) Batteries: Some older hybrid cars use these. They're like a middle ground between old-school batteries and Li-ion. They're not as powerful as Li-ion but better than regular batteries.
c) Solid-State Batteries: These are like the newer version of Li-ion batteries. They are lighter, charge faster, and might make future electric cars even better. They are still in the lab and not in many cars yet.

d) Lead-Acid Batteries: You might have heard of these in regular cars. They're heavy and not so great for electric cars, but they're simple and cheap. They are used in smaller, slower Electric Vehicles.
e) Sodium-Ion Batteries: These are a bit like Li-ion batteries but use sodium instead of lithium. They are still being worked on and might be used more in the future because sodium is easier to find.

Lithium-ion batteries are the most common type of battery used in Electric Vehicle battery packs. They are known for their high energy density, which allows them to store a lot of energy in a relatively small and lightweight package. This makes them ideal for use in Electric Vehicles, where weight and space are at a premium.

The capacity of an Electric Vehicle battery pack is typically measured in kilowatt-hours (kWh). The higher the capacity of the battery pack, the more energy it can store and the longer the vehicle's range will be. For example, a typical Electric Vehicle might have a battery pack with a capacity of around 50 kWh, which could provide a range of 200-250 Km on a single charge.

Fig. 2.9: Battery Pack

The battery pack also includes a variety of safety features to prevent overcharging, overheating, and other potential hazards. These safety features may include temperature sensors, voltage sensors, and circuit breakers, among others.

2. Electric Motor

The electric motor is the component that converts electrical energy stored in the battery pack into mechanical energy, which is used to

propel the vehicle. Electric motors (as shown in Fig. 2.10) can be either AC or DC motors. AC motors are more efficient and offer better performance, but they are more expensive than DC motors.

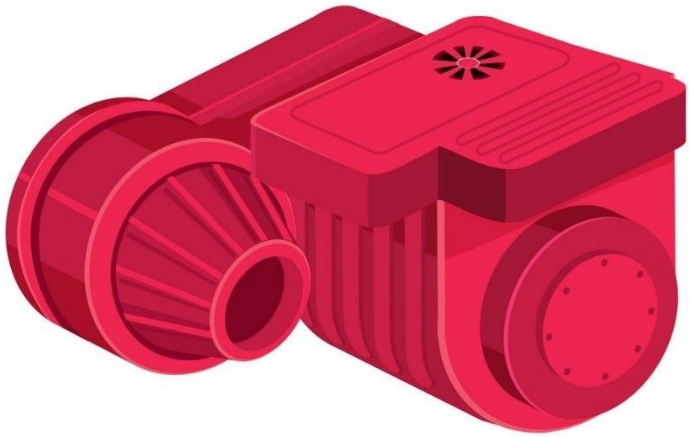


Fig. 2.10: Electric Traction Motor

The electric motor is the primary source of propulsion in an Electric Vehicle. Unlike a traditional internal combustion engine, which burns fuel to create mechanical power, an electric motor uses electrical energy from the battery pack to produce rotational motion.

Electric motors come in many different sizes and configurations, but they all operate on the same basic principles. At their core, electric motors consist of a stationary component called the stator, and a rotating component called the rotor. The stator contains a series of copper windings that create a magnetic field when an electric current is passed through them. The rotor, which is usually made of a series of permanent magnets, is attracted to the magnetic field created by the stator, causing it to rotate.

The speed and torque of the electric motor can be controlled by adjusting the amount of current supplied to the stator windings. This is typically done using a device called an inverter, which converts the DC power from the battery pack into AC power that can be used by the electric motor.

The electric motor can also be used to help slow the vehicle down during braking. This is known as regenerative braking, and it works by using the electric motor as a generator to convert the vehicle's kinetic energy back into electrical energy, which is then stored in the battery pack for

later use. Some components of Electric motor (as shown in fig. 2.11) are discussed below:

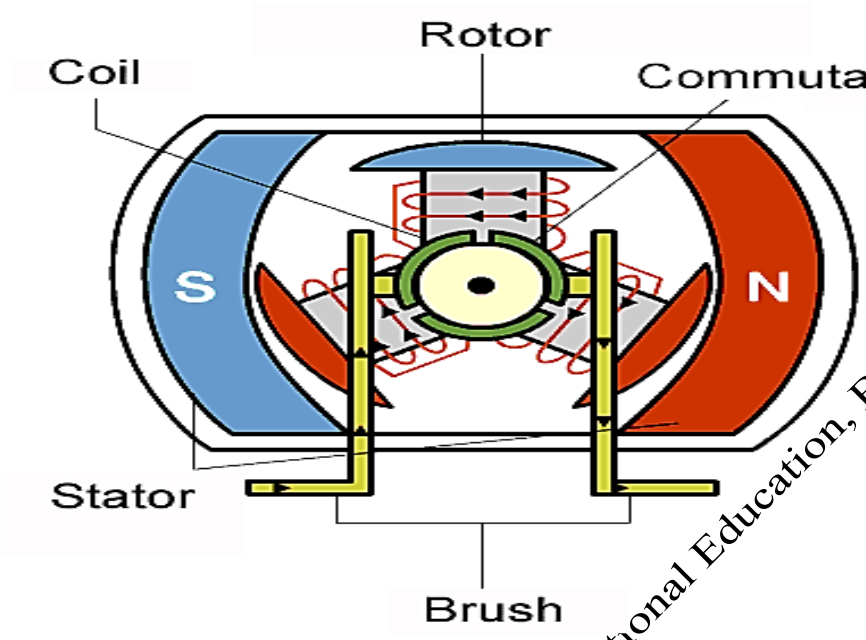


Fig. 2.11: Components of Electric Traction Motor

I. **Stator:** The stator is the stationary part of the motor and consists of a series of copper windings that are arranged in a specific pattern. When an electric current is passed through these windings, they create a magnetic field that interacts with the rotor to produce rotational motion.

II. **Rotor:** The rotor is the rotating part of the motor and consists of a series of permanent magnets that are arranged in a specific pattern. When the magnetic field from the stator interacts with the magnetic field from the rotor, it causes the rotor to rotate.

III. **Commutator:** The commutator is a segmented metallic ring that is mounted on the rotor shaft. It is used to switch the direction of the electric current flowing through the motor's windings as the rotor rotates. This ensures that the magnetic field in the stator continues to interact with the magnetic field in the rotor, producing continuous rotational motion.

IV. **Brushes:** The brushes are metallic contacts that ride on the commutator segments and conduct electricity from the power source to the motor's windings. They are typically made from materials such as Carbon or graphite, which are able to withstand the high temperatures and friction associated with motor operation.

V. **Bearings:** The bearings are used to support the rotor and allow it to rotate smoothly and with minimal friction. They are typically made

from materials such as steel or ceramic and are designed to withstand the high loads and speeds associated with motor operation.

VI. **Enclosure:** The enclosure is the outer casing that houses the motor's components and protects them from the environment. It is typically made from materials such as steel or Aluminium and may be designed to provide additional cooling or heat dissipation to help regulate the motor's temperature.

Various types of Electric Motors Used in Electric Vehicles:

Electric Vehicles (EVs) use various types of electric motors to drive their wheels. The choice of motor type can depend on factors like efficiency, power requirements, and cost. Here are some common types of electric motors used in Electric Vehicles, along with examples:

i. Brushless DC (BLDC) Motors: BLDC motors are widely used in Electric Vehicles due to their high efficiency and reliability. They do not require brushes, which reduces maintenance needs. Tesla Model 3 uses a rear-wheel-drive configuration with a three-phase, six-pole, internal permanent magnet synchronous motor.

ii. Permanent Magnet Synchronous Motors (PMSM): PMSM motors have permanent magnets on the rotor and are known for their efficiency and precise control. The Nissan Leaf, for example, uses a PMSM motor in some models.

ii. Induction Motors: These motors do not have permanent magnets and work on the principle of electromagnetic induction. The Tesla Model S uses a three-phase, four-pole induction motor.

iv. Switched Reluctance Motors (SRM): SRM motors have gained attention for their potential to offer high efficiency and reduced cost. While not as common as other types, they are being explored for EV applications by manufacturers like Nidec and Mahindra Electric.

v. Axial Flux Motors: Axial flux motors have a unique design where the magnetic field runs parallel to the rotor's axis. They are lighter and more compact, making them suitable for some EVs.

3. Motor Controller

The motor controller is an electronic device that controls the speed and torque of the electric motor. It receives input from the accelerator pedal and adjusts the power output of the electric motor accordingly. It is responsible for controlling the speed, torque, and direction of the

electric motor, based on input from the vehicle's accelerator pedal and other control systems.

The motor controller (as shown in Fig. 2.12) works by receiving signals from various sensors throughout the vehicle, such as the accelerator pedal position sensor and the motor temperature sensor. It then uses this information to determine how much current to send to the electric motor, to achieve the desired level of performance.

Fig. 2.12: Motor Controller

The motor controller typically consists of several key components, including a microprocessor, power transistors, and various control circuitry. The microprocessor acts as the brain of the motor controller, receiving input from the sensors and using algorithms to determine the appropriate level of power to send to the motor. The power transistors are responsible for switching the high-voltage power from the battery pack to the electric motor, and the control circuitry helps to regulate the voltage and current levels to ensure safe and efficient operation.

4. On-board Charger

The on-board charger is the component that is used to charge the battery pack of the Electric Vehicle. It converts AC power from the charging station into DC power that is used to charge the battery pack. On-board chargers can be either single-phase or three-phase chargers.

An on-board charger (shown as Fig 2.13) is an essential component of an Electric Vehicle (EV) that is responsible for converting AC power from an external source, such as a charging station or a wall outlet, into DC power that can be stored in the vehicle's battery pack. The on-board charger is typically located within the vehicle and is designed to be compact and efficient, while also meeting the safety and performance standards required for EVs.

Fig 2.13: onboard charger of an Electric Vehicle

5. DC-DC Converter

The DC-DC converter is an electronic device that converts high-voltage DC power from the battery pack into low-voltage DC power that is used to power other components of the Electric Vehicle, such as the lights, air conditioner, and entertainment system.

The DC-DC converter operates in several different modes depending on the power requirements of the low-voltage electrical systems. When the vehicle's electrical systems are idle, the DC-DC converter may operate in a standby mode, consuming minimal power to maintain the low-voltage system voltage level. When the vehicle's electrical systems are active, the DC-DC converter may operate in a boost mode, where it increases the voltage of the battery pack to match the required output voltage of the low-voltage system.

The operation of the DC-DC converter involves a complex interplay between these components, with the switching circuit controlling the flow of current through the inductor and capacitor, resulting in a smooth and stable output voltage. The output voltage of the DC-DC converter can be controlled by adjusting the duty cycle and frequency of the switching circuit, allowing for precise regulation of the output voltage. The DC-DC converter (as shown in Fig. 2.14) plays a critical

role in many modern electronic systems, enabling efficient power management and ensuring that devices operate reliably and safely.

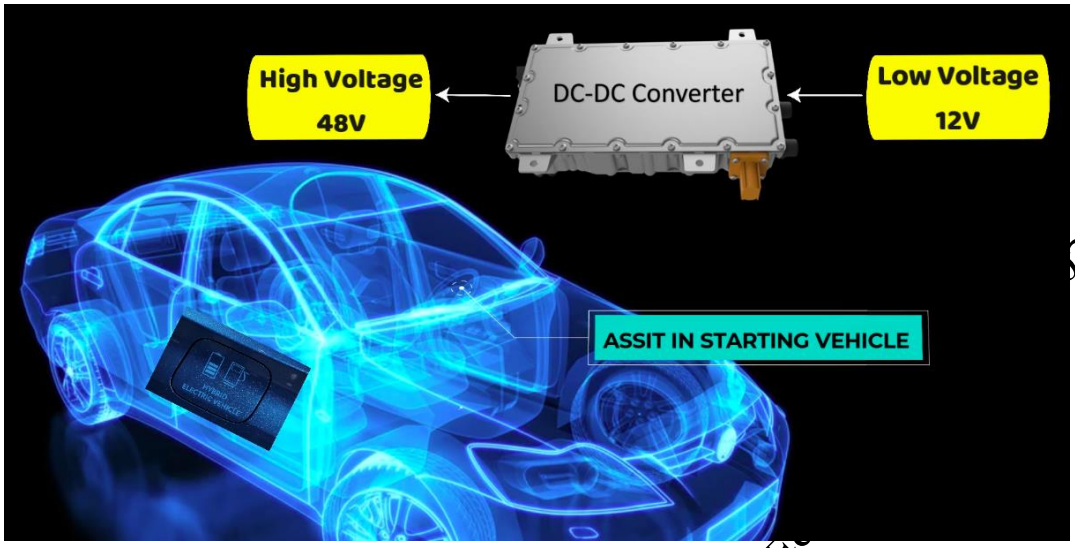


Fig 2.14: DC-DC converter

6. Vehicle Control Unit

The Vehicle Control Unit (VCU) is an electronic device that controls various components of the Electric Vehicle, such as the motor controller, battery pack, and on-board charger. The VCU also collects data from various sensors in the vehicle and uses this data to optimise the performance and efficiency of the Electric Vehicle.

A Vehicle Control Unit is like the brain of an Electric Vehicle. It's a computer that controls how the car moves and operates. The Vehicle Control Unit receives information from sensors all around the car, like the speed of the wheels and the position of the accelerator pedal. Based on this information, the Vehicle Control Unit tells the motor how fast to spin and how much power to use.

The Vehicle Control Unit also manages the battery, making sure it's charged and ready to go. It can even help the car use less energy by turning off certain systems when they're not needed. It also helps to regulate the heating and cooling system of the car, so you can stay comfortable on hot or cold days.

The Vehicle Control Unit (as shown in Fig. 2.15) also monitors the safety systems of the car, like the airbags and brakes. If there is a problem with any of these systems, the VCU will send a signal to alert the driver. Another important function of the VCU is managing the charging of the

battery. It makes sure the battery is charged properly and efficiently, so you can get the most out of your Electric Vehicle.

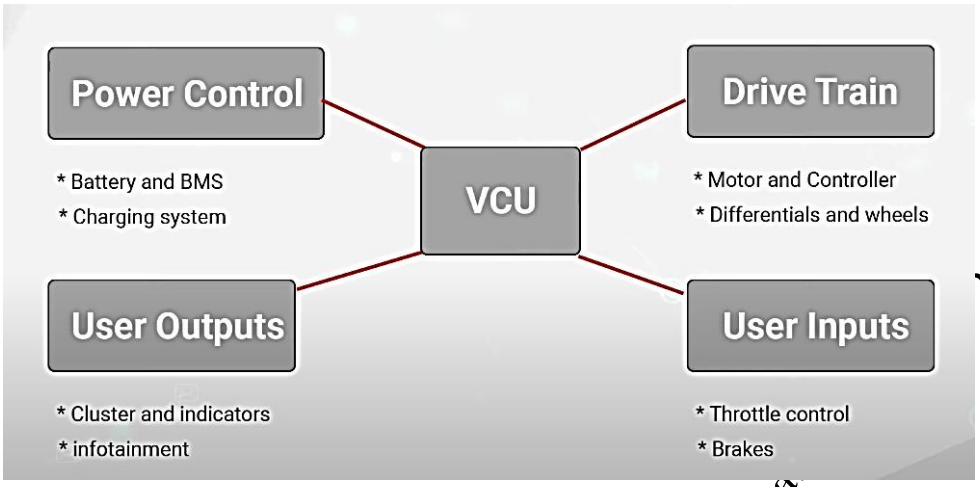


Fig 2.15: Flow Diagram of The Vehicle Control Unit

7. Battery Management System

The Battery Management System (BMS) is responsible for monitoring and controlling the battery pack. It ensures that each battery cell is operating within its safe operating range and prevents overcharging or overheating of the battery pack.

A Battery Management System (BMS) is a special system that helps Electric Vehicles (EVs) to manage their batteries. EVs are powered by big batteries that need to be needs to be properly taken care of, make sure they work well and last a long time. The BMS helps monitor the battery's temperature, voltage, and other important information. It also helps control the charging and discharging of the battery so that it stays within safe limits.

By taking care of the battery with the help of the BMS, EVs can go further and run better, making them a better option for the environment and saving money on gas in the long run.

8. Charging Port

Charging ports are an important component of Electric Vehicles (EVs), as they are used to recharge the vehicle's battery. There are different types of charging ports, which vary in terms of their charging speed and compatibility with different types of EVs. Here are the main types of charging ports used in EVs:

a. Level 1 Charging: This is the slowest type of charging, and it uses a standard 120-volt electrical outlet. Level 1 charging typically provides a charging rate of 4-5 miles of range per hour. This type of charging is suitable for plug-in hybrids and EVs with small batteries.
b. Level 2 Charging: This type of charging uses a 240-volt AC power supply and provides a charging rate of 10-20 miles of range per hour. Level 2 charging is suitable for most EVs, and it is the most common type of charging port found in public charging stations and home charging stations.

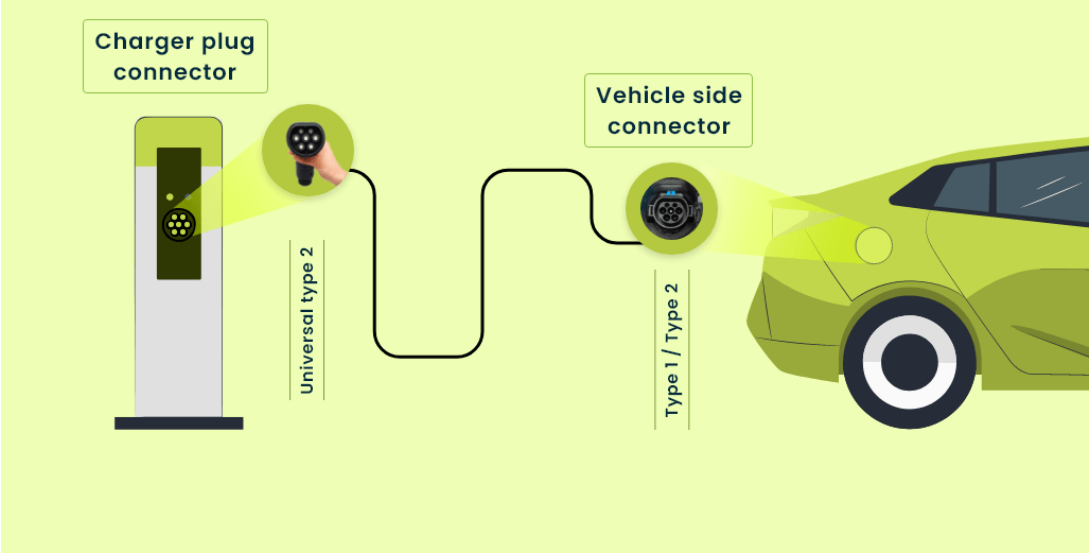


Fig. 2.16: Basic three types of EV chargers

c. DC Fast Charging: This is the fastest type of charging, and it uses a direct current (DC) power supply. DC fast charging can provide a charging rate of up to 80% in as little as 30 minutes, depending on the EV and the charging station. DC fast charging is ideal for long-distance travel and is commonly found at public charging stations.
d. Tesla Supercharger: This type of charging port is exclusive to Tesla vehicles and uses a proprietary charging standard. Tesla Superchargers can provide a charging rate of up to 170 miles of range in 30 minutes, depending on the Tesla model and the charging station.

Charging ports can also be categorised based on the shape of the plug and socket. The most common types of plugs and sockets are:

(i) J1772: This is the standard plug used for Level 1 and Level 2 charging in North America. It has a rectangular shape and is compatible with most EVs.

(ii) CCS: Combined Charging System (CCS) is a type of DC fast charging port that has been adopted by most automakers. It combines the J1772 AC plug with two additional DC pins to enable fast charging.

(iii) CHAdeMO: This is a DC fast charging port developed by Japanese automakers. It uses a round plug and is compatible with some EVs, but it is not as widely adopted as CCS.

9. Electric Powertrain

The Electric Powertrain is the combination of components that work together to propel the vehicle. It includes the electric motor, motor controller, battery pack, and other components that make up the drivetrain of the Electric Vehicle.

10. Electric Vehicle Inverter

The Electric Vehicle Inverter is an electronic device that converts DC power from the battery pack into AC power that is used to power the electric motor. It also converts AC power generated by the electric motor during regenerative braking into DC power that is used to charge the battery pack.

Electric Vehicles rely on a unique set of components to operate. These components include the battery pack, electric motor, motor controller, on-board charger, DC-DC converter, thermal management system, regenerative braking system, vehicle control unit, and various other components that make up the drivetrain and other systems of the Electric Vehicle. As Electric Vehicles become more popular, it is likely that we will see further advancements in the design and functionality of these components.

11. Wire Harness

An electric vehicle (EV) relies on a complex system known as a wiring harness to manage its electrical connections. This wiring harness is akin to the vehicle's electrical circulatory system, serving as a network of wires, connectors, and components that facilitates the flow of power and data to various parts of the EV. Here's a more detailed breakdown of what a wiring harness does in an electric vehicle:

1. Wires and Cables: At its core, a wiring harness consists of electrical wires and cables. These conductive materials, often made of copper or aluminum, are responsible for carrying electricity from the EV's power

source, typically a high-voltage battery, to the numerous electrical components like the motor, lights, sensors, and control units.

2. Connectors: The harness includes an array of connectors, plugs, and sockets. These connectors act as the bridge between individual wires and the different components, ensuring a secure and dependable connection. They also make assembly and disassembly processes more straightforward during manufacturing, maintenance, or repairs.
3. Protection and Insulation: To safeguard the wires from environmental factors such as moisture, heat, and mechanical stress, they are typically bundled together and enclosed in protective sheaths or sleeves. This insulation is crucial for preventing short circuits and ensuring safety.
4. Routing and Organization: The harness is intricately designed and routed throughout the EV to maintain an organized and efficient layout. This strategic organization minimizes the risk of interference between wires, reduces overall weight and bulk, and makes it easier to trace and resolve electrical issues.
5. Safety Measures: Safety is a paramount concern in EV design. Wiring harnesses are equipped with safety features like fuses and circuit breakers to protect the electrical system from overloads and short circuits. These safety mechanisms help prevent accidents and maintain the vehicle's reliability.
6. Integration: The wiring harness serves as the vital link between different EV components, including the electric motor, battery management system, charging system, control units, sensors, lights, and more. This integration enables these components to communicate and collaborate harmoniously, ensuring the EV operates as intended.
7. EMI Reduction: Wiring harnesses are thoughtfully designed to minimize electromagnetic interference (EMI), which can disrupt sensitive electronics. Techniques like proper grounding and shielding are employed to achieve this.
8. Diagnostic Capabilities: Many modern EV wiring harnesses come with diagnostic capabilities that allow the vehicle's onboard computer systems to monitor the health and performance of various electrical components. This feature streamlines troubleshooting during maintenance and repairs by providing timely and accurate information.

Check Your Progress

A. Fill in the Blanks:

1) _____ is the most common type of battery used in Electric Vehicles.

2) _____ is the component which is used to control the vehicle's speed and direction?

B. Multiple Choice Questions:

1. Which component stores electrical energy used to power the electric motor in an Electric Vehicle?
a) Electric motor
b) Motor controller
c) Battery pack
d) On-board charger

2. What component converts electrical energy from the battery into mechanical energy to propel the vehicle forward?
a) Motor controller
b) Electric motor
c) On-board charger
d) DC-DC converter

3. Which component controls the speed and torque of the electric motor?
a) Battery pack
b) Electric motor
c) Motor controller
d) Transmission system

4. What is the function of the on-board charger in an Electric Vehicle?
a) Converts AC power to DC power for the battery pack
b) Converts DC power to AC power for the electric motor
c) Converts high-voltage DC power to low-voltage DC power
d) Controls the speed and torque of the electric motor

C. Answer the Following Questions:

1. What is the main function of the battery pack in an Electric Vehicle? What is the most common type of battery used in Electric Vehicles?
2. What is the function of the motor controller?
3. What is the function of the vehicle control unit?

Activity

1. Identify the Charging ports or charging infrastructures nearby your city.

2. Identify the components of EV.
3. Note down the given specification and technical details of components used in EV.
4. Compare the model of Electric Vehicle's specification between different components (two-wheeler, etc.)

Session 3: Differentiate Between Conventional Vehicles and Electric Vehicles

Electric motors already occupy an important place in our everyday lives. They are found in many everyday items such as electric toothbrushes, washing machines, and coffee machines. Electric cars, in particular, are bringing electric motors even more into focus. They also have to compete with conventional internal combustion engines.

But what are the differences between these two types of drive? We got to the bottom of this question and provide you with the answers in this session.

INTERNAL COMBUSTION ENGINE

An internal combustion engine consists of the following components: Combustion chamber, intake and exhaust valves, piston, connecting rod, crankshaft and, if applicable, a spark plug. Four steps must be performed to make a car drive.

1. Priming: The piston moves downwards in the combustion chamber and draws an air–petrol mixture (in the case of diesel, only air) through the intake valve into the combustion chamber.
2. Compression: The piston moves upwards and thus compresses the mixture of air that has flowed in. The inlet and outlet valves are closed so that nothing can escape.
3. Operation: If the pressure is high enough, the spark plug produces a spark, and the mixture explodes. In the case of diesel vehicles, the fuel is injected into the combustion chamber, where it self-ignites because of the high pressure and temperature. The explosion pushes the piston down – the engine is in operation.
4. Emission: The piston moves up again, the exhaust valve is open, and the exhaust gases escape.

An internal combustion engine consists of several pistons, which are attached to the crankshaft using the connecting rod. The movement resulting from the combustion of the fuel is used to move the car forward.

Comparison between IC Engine Vehicle and Electric Vehicle

The following table highlights the points that differentiate an IC Engine Vehicle from an Electric Vehicle –

Point of Comparison	Internal Combustion Engine (ICE) Vehicles	Electric Vehicles (EVs)
Source of power	Different types of fuels such as Diesel /Petrol/ CNG etc.	Electricity obtained from charged batteries, ultra-capacitors, etc.
Prime mover	Engine	Electric motors
Power density (Fuel)	High power density.	Power source is low.
Impact on Environment	ICE Vehicle emits green-house gases and sound pollution which have adverse effect on environment.	EVs does not have adverse effect on environment.
Travelling distance	• In a two-wheeler, it can travel more than 400 km on a single tank of fuel. • In a four-wheeler, you can go more than 1000km per fill.	• Two-wheeler EVs travel up to 150 km per charge. • Four-wheelers travel up to 1000 km per fill.
Refueling/ charging time	ICE Vehicle requires less refilling time (approx. less than 5 min.).	EVs have a long charging time, about 0.5 to 8 hours.
Space and weight fuel tank	The fuel tank occupies minimal space and the weight of the fuel is relatively low.	The batter bank takes large. Also, the batteries are very heavy.
Maintenance and running costs	The maintenance and running costs of internal combustion engine vehicles are high.	The Electric Vehicles require low running and maintenance costs.
Efficiency	The efficiency of IC engines is about 30%.	The electric motors used in Electric Vehicles have approximately 80% efficiency.
Noise pollution	IC engine vehicles produce noise.	Electric Vehicles have No Noise
Time required for maximum torque	IC engine vehicles require to pick up some speed to deliver maximum torque.	Electric Vehicles produce maximum torque instantly after starting of motor.
Capital cost	IC engine vehicles have an average initial cost.	The initial cost of Electric Vehicles is comparatively high.

Power transmission	In IC engine vehicles, the system of power transmission from source to load is mechanical only.	Electric Vehicles have both mechanical as well as electrical power transmission system.

Check Your Progress

A. Fill in the Blanks:

A. In the case of diesel vehicles, the fuel self-ignites because of the high pressure and temperature in the _____.

B. Electric Vehicles require a long charging time, about 0.5 to 8 hours, compared to internal combustion engine vehicles, which require less refilling time of approximately less than _____ minutes.

C. The efficiency of electric motors used in Electric Vehicles is approximately _____.

D. Electric Vehicles have a noise-free operation compared to internal combustion engine vehicles, which produce _____.

B. Multiple Choice Questions:

1. What is the source of power for internal combustion engine vehicles?
a) Electricity
b) Gasoline
c) Solar energy
d) Wind power

2. What is the prime mover or powertrain in Electric Vehicles?
a) Gasoline engine
b) Electric motor
c) Diesel engine
d) Wind turbine

3. What is the specific energy of the fuel used in internal combustion engine vehicles?
a) High
b) Low
c) Moderate
d) Variable

4. What is the impact of internal combustion engine vehicles on the environment?
a) Adverse effect
b) No effect
c) Positive effect
d) Variable effect

5. What is the traveling distance per charge for Electric Vehicles?
a) More than 300 miles
b) Around 100 miles
c) Less than 50 miles
d) It varies based on the vehicle type

C. Answer the following questions:

1. Can you describe the four steps involved in the operation of an internal combustion engine?
2. How does the source of power differ between internal combustion engine vehicles and Electric Vehicles?
3. What environmental impact is associated with internal combustion engine vehicles, and how does it compare to Electric Vehicles?

Activity

1. Draw a neat and clean diagram of an Internal Combustion Engine and label the key components of systems.
2. Calculate and compare the refuelling time and traveling distance for both Internal Combustion Engine vehicles and Electric Vehicles.

Module 3	Electric and Electrical Systems of Electric Vehicles

Module Overview

Electric Vehicles (EVs) have become increasingly popular in recent years, as people look for alternatives to gasoline-powered cars. Unlike traditional vehicles that rely on internal combustion engines, EVs use an electric motor to propel the vehicle. As a result, they require a different set of components to function.

Electricity is a type of energy that is created by the flow of tiny particles called electrons through a conductor. It is a key component in the operation of Electric Vehicles (EVs), which use electric motors powered by batteries to propel them. To understand EVs, it's an important part of how Electric Vehicles (EVs) work. Here are some basic terms related to electricity that you should know: In this unit, we will discuss the various components that make up an Electric Vehicle.

Learning Outcome

After completing this module, you will be able to:

- Understand and explain the basic principles of electricity, including voltage, current, resistance, and power.
- Identify and describe the fundamental concepts of electric circuits, including series and parallel circuits.
- Understand the function of various electrical components represented by these symbols, such as resistors, capacitors, diodes, and transistors.
- Identify and describe the different types of sensors used in electric vehicles, including temperature sensors, speed sensors, and position sensors.

Module Structure

Session 1: Fundamentals of Electricity and Terminology
Session 2: Common Electrical and Electronics Symbols
Session 3: Sensors Used in Electric Vehicles

Session 1: Fundamentals of Electricity and Terminology

Electricity is a kind of energy that comes from charged particles like electrons and protons. It's a fundamental force of nature and important in our modern world. Electricity can show up in different forms, but the most common one is electrical current. This is when electrons move through things like wires. This movement of electrons is what makes all our devices work, like lights, appliances, and gadgets.

We can create electricity in different ways, such as through chemical reactions in batteries, or by using generators that make electricity from things like magnets and coils. We can even get electricity from eco-friendly sources like solar panels and wind turbines.

For example, when you turn on a light switch, you complete an electrical circuit, and electricity flows through the wire in the circuit. This electricity powers the light bulb, causing it to glow and give off light. Electricity can be dangerous if we don't use it safely, so it's important to always follow safety rules and instructions when using electrical devices. But if we use it safely, electricity can be very helpful and make our lives easier and more comfortable.

Electricity is a type of energy that powers many things we use every day, like lights, televisions, and computers. It is created when tiny particles called electrons move through a conductor, which is usually a metal wire.

There are three main parts of electricity: voltage, current, and resistance.

a) **Voltage** is a measure of the electrical potential difference between two points in a circuit. It is the force that pushes electricity through a circuit from higher to lower potential. The S.I unit of measurement for voltage is **volts (V).**

Example: When you plug in your phone charger, the voltage from the outlet pushes electricity through the charger and into your phone. When you use a battery to power a device, the voltage rating of the battery determines how much force is pushing the electricity through the circuit. A higher voltage battery can power devices that require more electricity.

b) **Current** is the rate of flow of electrical charge in a circuit from higher to lower potential. The S.I unit of measurement for current is **ampere (A)** which indicates how much electricity is flowing at a given time.

Example: When you turn on a light switch, the current flows through the wire in the circuit and powers the light bulb, causing it to light up.

c) **Resistance** is the measure of how much a material resists (opposes) the flow of current or it is the property of conductor material to opposes the flow of current. The S.I unit of measurement for resistance is **ohms (Ω).**

Example: When you use a resistor in an electrical circuit, it limits the flow of current, which can help protect other components in the circuit from getting too much electricity.

d) **Ohm's law** is a fundamental law in electricity that explains how voltage, current, and resistance are related. It states that the current flowing through a conductor is directly proportional to the voltage applied across it, and inversely proportional to the resistance of the conductor.

Ohm's Law defines the correlation between electric current (I), voltage (V), and resistance (R) in a conductor.
Ohm's Law can be expressed as: V = I × R
Where: V = volts, I = amps, R = ohms

Example: Imagine you have a battery with a voltage of 9 volts (V) and a light bulb with a resistance of 3 ohms (Ω). According to Ohm's law, the current flowing through the circuit would be 3 amperes (A) (9V / 3Ω = 3A). This means that the light bulb would light up with a certain brightness, depending on its wattage.

Example: If you have a 12-volt battery and a resistor with a resistance of 4 ohms, the current flowing through the resistor will be 3 amps (according to Ohm's Law: I = V/R).

e) **Power -** Power is the rate at which work is done or energy is transferred. In electrical engineering, it is measured in watts and indicates how much energy is being used or produced by an electrical system.

Example: When you turn on a light bulb, the power rating of the bulb tells you how much energy it uses to produce light. A higher wattage bulb uses more energy and produces more light.

f) **Watt -** Watt is the unit of measurement for power. It tells us how much energy is being used per second.

Example: When you look at the label on a light bulb, it will tell you how many watts it uses. A 60-watt bulb uses more energy than a 40-watt bulb, which means it will be brighter but also use more electricity.

g) **Circuit** - A circuit is a path for electricity to flow through. It usually includes a source of electricity (like a battery or outlet), wires to carry the electricity, and a device that uses the electricity (like a light bulb or motor).

Example: When you turn on a light switch, you are completing a circuit that allows electricity to flow from the power source, through the wires, and into the light bulb, causing it to light up.

Example: When you connect a battery to a light bulb with wires, you create a circuit that allows the electricity to flow through the bulb and make it light up.

h) **Conductor -** A conductor is a material that allows electricity to flow through it easily. Most metals, like copper and aluminum, are good conductors.

Example: When you use copper wire to connect components in an electrical circuit, the electricity flows through the wire easily because copper is a good conductor.

i) **Insulator -** An insulator is a material that does not allow electricity to flow through it easily. Materials like rubber, plastic, and glass are good insulators.

Example: When you use a rubber coating on a wire, it helps to insulate the wire and prevent electricity from flowing where it shouldn't, which can help prevent electrical shocks.

j) **Circuit Breaker -** A circuit breaker is a safety device that is designed to protect electrical circuits from overloading or short circuits. It is usually installed in the electrical panel of a building and will trip or shut off the circuit if it detects an overload or short circuit.

Example: If you have too many appliances plugged into a single outlet, the circuit breaker may trip, shutting off the circuit and preventing damage to the electrical system.

k) **Series Circuit** - A series circuit is a type of electrical circuit in which the components are connected one after the other in a single path. In

a series circuit, the same current flows through each component, and the voltage is divided among the components.

Example: A string of Christmas lights is an example of a series circuit. If one bulb burns out, the entire string will not light up because the circuit is broken.

l) **Parallel Circuit** - A parallel circuit is a type of electrical circuit in which the components are connected in multiple paths. In a parallel circuit, the voltage across each component is the same, while the current is divided among the components.

Example: The outlets in your home are connected in a parallel circuit. Each outlet has the same voltage, but the current is divided among the devices that are plugged into them.

m) **Ground** - Ground is a reference point for electrical circuits. It is often connected to the earth's surface to provide a safe path for excess electrical current to flow to the earth.

Example: When you plug in a device to an electrical outlet, the ground wire in the plug connects to the metal case of the device. If there is a short circuit, the excess current can flow through the ground wire and into the earth, preventing electrical shock to the user.

n) **Capacitor** - A capacitor is a component that can store electrical charge. It is made up of two conductive plates separated by an insulating material.

Example: When you use a capacitor in an electrical circuit, it can help regulate the flow of current and prevent sudden spikes or drops in voltage. Capacitors are often used in electronic devices like radios and televisions.

o) **Transformer** - A transformer is a component that can change the voltage level of electrical current. It consists of two coils of wire wrapped around a magnetic core.

Example: When you use a transformer in an electrical circuit, it can step up or step down the voltage level of the current, depending on the number of turns in each coil. Transformers are often used in power supplies and electrical grids.

p) **AC and DC** - AC (alternating current) and DC (direct current) are two types of electrical current. AC changes direction periodically, while DC current flows in one direction only.

Example: Most household electrical devices use AC current, which is supplied by the power grid. Devices that use batteries, such as flashlights or portable radios, use DC current.

q) **Capacitance** - Capacitance is a measure of an object's ability to store electrical charge. It is measured in farads and is affected by the object's size, shape, and proximity to other charged objects.

Example: A capacitor is a device that is designed to store electrical charge. It is made up of two conductive plates separated by a dielectric material, which helps to increase the capacitance of the device.

r) **Inductance** - Inductance is a property of a circuit or component that resists changes in the flow of electrical current. It is measured in henries and is affected by the number of turns in a coil, the size of the coil, and the type of core material used.

Example: An inductor is a component that is used to store energy in a magnetic field. It is made up of a coil of wire that is wound around a core material, such as iron. When electrical current flows through the coil, it creates a magnetic field that stores energy.

s) **Diode** - A diode is a component that allows electrical current to flow in one direction only. It is made up of a semiconductor material, such as silicon, and has a cathode and an anode.

Example: Diodes are commonly used in rectifier circuits, which are used to convert Alternate current into Direct current. The diode allows current to flow in one direction only, which helps to ensure that the resulting Direct current is consistent.

t) **Transistor** - A transistor is a semiconductor device that can be used to amplify or switch electrical signals. It has three terminals, called the emitter, base, and collector.

Example: Transistors are used in a wide range of electronic devices, including radios, televisions, and computers. They can be used to amplify weak signals or to switch signals on and off, allowing for the creation of complex circuits.

u) **Transformer** - A transformer is a device that is used to transfer electrical energy from one circuit to another by means of electromagnetic induction. It is made up of two coils of wire, called the primary and secondary coils, that are wound around a core material, such as iron.

Example: A transformer is used to step up or step down the voltage of an electrical signal. For example, a step-up transformer is used to increase the voltage of a signal to a higher level, while a step-down transformer is used to decrease the voltage of a signal to a lower level.

Check Your Progress

A. Answer the Following Questions:

1. What is electricity and how does it make things work?
2. Describe Ohm's law and its relationship between voltage, current, and resistance.
3. Explain the unit of measurement for power, the watt, and its significance.
4. What is a circuit, and what are its essential components? Differentiate between a series circuit and a parallel circuit.
5. What is the difference between AC and DC ?

B. Fill in the Blanks:

1. _____ is a measure of the electrical potential difference between two points in a circuit.
2. _____ is the flow of electricity through a wire or Current is the flow of electrical charge in a circuit.
3. _____ is the measure of how much a material resists (opposes) the flow of electricity.
4. A _____ is a component that can store electrical charge.

C. Multiple Choice Questions:

1. What are the tiny particles that move through a conductor and carry energy with them?

a) Protons
b) Neutrons
c) Electrons
d) Photons

2. What is the measure of the electrical potential difference between two points in a circuit?
a) Voltage
b) Current
c) Resistance
d) Capacitance

3. Which law explains the relationship between voltage, current, and resistance?
a) Newton's Law
b) Ohm's Law
c) Einstein's Law
d) Kepler's Law

4. Which type of circuit is a single path for electricity to flow through?
a) Series circuit
b) Parallel circuit
c) Ground circuit
d) Capacitor circuit

5. What is the reference point for electrical circuits that provides a safe path for excess current?
a) Voltage
b) Current
c) Resistance
d) Ground

6. What is a device that can change the voltage level of electrical current?
a) Transformer
b) Diode
c) Capacitor
d) Transistor

Activity

1. **List the components of electric components in EVs to find the current, ampere and voltage mentioned in components.**

S. No.	Electric components	Voltage	Ampere	Current
1.				

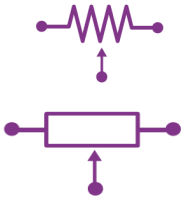
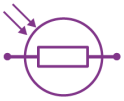
	2.				
	3.				
	4.				
	5.				

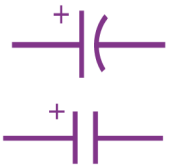
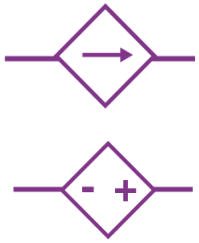
Session 2: Common Electrical and Electronics Symbols

As we are drawing any circuit diagram so we can't draw the actual components or the part that we need to make a circuit. So, to overcome this problem we use electronic symbols because they are easy to draw and this makes circuit easily. Below is a list of the most commonly used electrical symbols.

3.1 Electrical Symbols

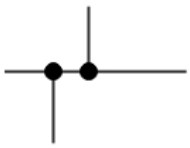
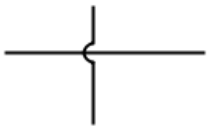
Electrical Wire	A wire is a single, usually cylindrical, flexible strand or rod of metal through which electric current flows. It is usually made of good conducting metals such as copper.	
Connected Wire	Connecting wires provide a medium to an electrical current so that they can travel from one point on a circuit to another.	
Disconnected Wire	In diagrams, we come across situations where we have wires crossing through other wires even though they are not connected to each other. Hence, it is preferred to have a hump as shown to depict the crossing of one wire over another wire.	
Earth Ground	The reference point in an electrical circuit from which voltages are measured, a common return path for electric current, or a direct physical connection to the earth.	

Chassis Ground	Chassis ground is the metal housing that some electrical device is encased in. The chassis may be connected to the green ground wire of your power lines.	
Digital/Common Ground	The reference voltage of digital logic ICs. This means that no analogue signals are coupled into this reference plane.	
Lamp/Light Bulb	It is a load that uses electric current to emanate light.	
Resistor (IEE)/(IEC)	A resistor is a device that resists the flow of current through a circuit.	 
Variable Resistor/ Rheostat (IEE)/(IEC)	A variable resistor is a resistor in which electrical resistance can be adjusted. A rheostat is a variable resistor in which resistance can be varied to control the current in the circuit.	 
Potentiometer (IEE)/(IEC)	A potentiometer is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider.	
Photoresistor/ Light-Dependent Resistor (LDR)	Photoresistor decreases resistance with respect to receiving luminosity.	
Thermistor	A thermistor is a type of resistor in which resistance is dependent on temperature.	

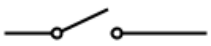
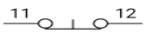
Capacitor	A capacitor is a device that stores electrical energy in an electric field.	
Variable Capacitor	A variable capacitor is a capacitor in which capacitance may be intentionally and repeatedly changed mechanically or electronically.	
Polarised Capacitor	A capacitor in which anode is made of metal forms an insulating oxide layer through anodisation.	
Voltage Source/ Current Source	A voltage source is an electrical component that can maintain a fixed voltage irrespective of the load resistance and output current.	
Battery Cell/ Battery	A battery is a device that consists of two or more electrochemical cells with external connections.	
AC Voltage Source	It is a source hose where positive and negative terminal change periodically.	
Controlled Voltage Source/ Controlled Current Source	A current-controlled voltage source produces a voltage that is linearly proportional to the current. A controlled or dependent current source, on the other hand, changes its available current depending upon the voltage.	
Voltmeter	The voltmeter is an instrument for measuring electrical potential.	
Ammeter	The Ammeter is an instrument for measuring electric current	

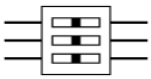
Diode	The diode is a semiconductor device with two terminals that allows current to flow only in one direction.	

Wires Symbols

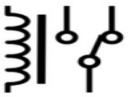
Symbol	Name	Description
	Electrical Wire	It is the symbol that is used to represent a wire.
	Connected Wires	This Symbol represents the wire connected crossing.
	Not Connect Wires	This Symbol shows that wires are not connected on crossing.

Switches Symbols

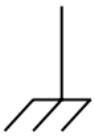
Symbol	Name	Description
	SPST (Single Pole Single Through) Toggle Switch	It is the symbol of a switch that disconnects current when open.
	SPDT (Single Pole Double Through) Toggle Switch	This symbol of switch selects between two connections.
	Push Button (N.O)	It is a symbol that denotes a Momentary switch - normally open.
	Push Button Switch (N.C)	This denotes the symbol of a Momentary switch - normally closed.

	DIP Switch	It is the symbol of the DIP switch which is used for onboard configuration.

Relays

Symbol	Name	Description
	SPST Relay	This shows the symbol of relay that closes the connection by an electromagnet.
	SPDT Relay	This shows the symbol of relay that opens the connection by an electromagnet.

Earthing

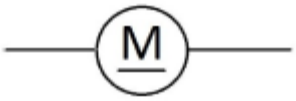
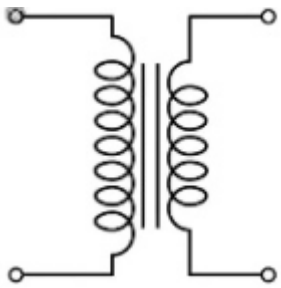
Symbol	Name	Description
	Earth Ground	This symbol is used for zero potential reference and electrical shock protection.
	Chassis Ground	This symbol shows the wire connected to the chassis of the circuit.
	Digital Ground	The hollow triangle usually means digital ground, but is often used as a reference ground. A letter or number in the triangle may be used to indicate references that are in common with each other

Inductors

Symbol	Name	Description

	Indicator	Symbol of a Coil / solenoid that generates a magnetic field.
	Iron Core Inductor	It is the symbol of the iron core inductor which includes iron.
	Variable Inductor	It is the coil or solenoid that has a variable magnetic field.

Motor and Transformer

Symbol	Name	Description
	Motor	Symbol of motor, which changes electric energy to kinetic energy.
	AC Transformer	Transformer changes AC voltage from high to low or low to high.

Check Your Progress

A. Multiple Choice Questions:

1. Which symbol is used to represent a wire in a circuit diagram?
a) Electrical Wire
b) Connected Wires
c) Not Connect Wires
d) Earth Ground

2. What does the symbol for Earth Ground represent?
a) A wire connected to the chassis of the circuit
b) A reference point for voltage measurement

c) A switch that disconnects current when open
d) A symbol of a coil/solenoid that generates a magnetic field

3. What is the function of a resistor in a circuit?
a) It stores electrical energy in an electric field
b) It resists the flow of current through a circuit
c) It generates a magnetic field
d) It changes electric energy to kinetic energy

4. What is the purpose of a capacitor in a circuit?
a) It stores electrical energy in an electric field
b) It adjusts the voltage in a circuit
c) It resists the flow of current through a circuit
d) It allows current to flow only in one direction

5. Which symbol represents a voltage source that can maintain a fixed voltage?
a) Battery Cell/Battery
b) AC Voltage Source
c) Controlled Voltage Source/Controlled Current Source
d) Voltmeter

6. What does the symbol for a diode represent?
a) A wire in a circuit diagram
b) A device that stores electrical energy in an electric field
c) A semiconductor device that allows current to flow in one direction
d) An instrument for measuring electrical potential

1. Answer the Following Question:

1. Why do we use electronic symbols in circuit diagrams instead of drawing the actual components? Discuss the advantages and ease of using symbols in circuit representation.
2. Explain the significance of Earth Ground in an electrical circuit. Discuss its role as a reference point for voltage measurement and a common return path for electric current.
3. Describe the characteristics and purpose of a potentiometer. How does it function as an adjustable voltage divider in a circuit?

Activity

1. Draw any circuit diagram using this symbol.
2. Find out the symbols in Electric Vehicle and identify them.

3. Perform the practical based on electric terms, laws and principles used in EV (Ohms, current, voltage, and resistance, power calculation, parallel and series circuits).

Session 3: Sensors Used in Electric Vehicles

Sensors are vital components in Electric Vehicles (EVs) that play a crucial role in ensuring their safe and efficient operation. These devices are responsible for gathering various types of data, such as temperature, speed, and distance, and then relaying this information to the vehicle's control systems. In this session, we'll explore the types of sensors commonly used in Electric Vehicles and their functions.

1. Proximity Sensors:

Proximity sensors are used in EVs to detect objects and obstacles in the vehicle's vicinity. These sensors help with features like parking assistance and collision avoidance.

Ultrasonic sensors and LiDAR sensors are commonly used for this purpose.

2. Temperature Sensors:

Temperature sensors monitor the temperature of critical components in the EV, such as the battery, motor, and inverter. Maintaining the right temperature is crucial for the efficiency and longevity of these components.

Thermocouples and thermistors are often employed as temperature sensors.

3. Speed Sensors:

Speed sensors measure the vehicle's velocity and help control its speed. They are crucial for functions like cruise control and anti-lock braking systems. Hall effect sensors and wheel speed sensors are common types of speed sensors.

4. Battery State-of-Charge (SoC) Sensors:

SoC sensors are essential for monitoring the amount of charge remaining in the EV's battery. They provide drivers with accurate information about their range and when to recharge. Coulomb counters and voltage-based sensors are used for SoC measurement.

5. Current Sensors:

Current sensors measure the flow of electric current in different parts of the EV. They help manage the power distribution and monitor the health of electrical components. Hall effect sensors and shunt resistors are frequently used for current measurement.

6. Acceleration Sensors:

Acceleration sensors, often referred to as accelerometers, detect changes in the vehicle's acceleration. They are crucial for features like stability control and airbag deployment. MEMS (Micro-Electro-Mechanical Systems) accelerometers are commonly used in EVs.

7. Position Sensors:

Position sensors determine the location of various components, such as the throttle position or the position of the steering wheel. They play a role in controlling various vehicle functions. Potentiometers and optical encoders are typical position sensors.

8. Pressure Sensors:

Pressure sensors are used to monitor air pressure in the tires and hydraulic systems. Maintaining the right tire pressure is essential for safety and energy efficiency. Piezoelectric pressure sensors and capacitive pressure sensors are commonly used.

Check your Progress

Fill in the Blanks;

1. Proximity sensors in Electric Vehicles are commonly used for features like _____ and collision avoidance.

2. Temperature sensors are crucial for monitoring the temperature of critical components in EVs, such as the battery, motor, and inverter, to ensure their efficiency and _____.

3. Speed sensors are essential for functions like cruise control and anti-lock braking systems, as they measure the vehicle's _____.

4. Battery State-of-Charge (SoC) sensors provide accurate information about the remaining charge in an EV's battery, helping drivers determine their _____.

5. Current sensors are used to measure the flow of electric current in different parts of the EV, assisting in managing power distribution and monitoring the health of _____ components.

Multiple-Choice Questions:

1. Which sensors are commonly used for detecting objects and obstacles in the vicinity of Electric Vehicles?
A) Temperature sensors
B) Speed sensors
C) Proximity sensors
D) Pressure sensors

2. What types of sensors are often employed to monitor the temperature of critical components in EVs?
A) Hall effect sensors
B) Ultrasonic sensors
C) Thermocouples and thermistors
D) Coulomb counters

3. Speed sensors are crucial for which functions in Electric Vehicles?
A) Airbag deployment
B) Cruise control and anti-lock braking systems
C) Parking assistance
D) Pressure monitoring

4. What do Battery State-of-Charge (SoC) sensors provide accurate information about in EVs?
A) Tire pressure
B) Remaining charge in the battery
C) Vehicle velocity
D) Ambient temperature

5. Which sensors measure the flow of electric current in different parts of an EV to manage power distribution and monitor the health of electrical components?
A) Hall effect sensors
B) Thermocouples
C) Potentiometers
D) Ultrasonic sensors

Answer the Following Questions:

1. What is the main role of sensors in Electric Vehicles (EVs)?
2. Name two types of sensors commonly used in EVs for detecting objects and obstacles in the vehicle's vicinity.
3. Why is monitoring the temperature of critical components in an EV, such as the battery and motor, crucial for their efficient operation?
4. Give an example of a function in Electric Vehicles that relies on speed sensors.
5. Which sensors are frequently used to measure the flow of electric current in different parts of an EV?
6. How does acceleration sensors (accelerometers) contribute to the safety and functionality of Electric Vehicles?

Module 4	Tools and Equipment Used in Workshop

Module Overview

A Workshop is a building where tools and machines are used for making or repairing things portable, including suspension for easy manual handling, e.g., in connection with spring-suspended portable apparatus for use along assembly lines.

In an EV workshop, various tools and equipment are essential for working with Electric Vehicles. Some of these tools include Multimeters, which help measure electrical currents and voltages, and battery analysers, which are used to check the health and performance of the EV's battery. In this workshop electric motor testing equipment also includes, which allows to examine and assess the electric motor that powers the vehicle.

Workshops have charging station equipment to understand how EVs get their power from electrical outlets. Also, Computer systems and software for diagnosing and troubleshooting any issues that might arise in an electric vehicle. In this Module, we will understand these kinds of tools and equipment which helps in building, repairing, and maintaining Electric Vehicles.

Learning Outcome

- Identify and describe the hand tools, hand cutting tools, measuring tools, power tools, and EV diagnostic tools commonly used in automotive and electrical work.
- Understand the proper usage and safety precautions for each hand tool.
- Demonstrate the ability to safely and effectively use hand cutting tools for various cutting tasks.
- Demonstrate accuracy in taking measurements using different measuring tools.
- Recognize and explain the various types of service equipment used in the maintenance and repair of electric vehicles, such as lifts, jacks, and stands.
- Demonstrate proficiency in setting up and operating service equipment for vehicle maintenance.

- Demonstrate the ability to safely and effectively operate power tools for various tasks.
- Identify and describe the different diagnostic tools used specifically for electric vehicles, such as OBD-II scanners, battery analysers, and thermal cameras.
- Understand the functions and importance of each diagnostic tool in the maintenance and repair of electric vehicles.
- Demonstrate proficiency in using diagnostic tools to troubleshoot and diagnose issues in electric vehicles.

Module Structure

Session 1: Hand Tools
Session 2: Hand Cutting Tools
Session 3: Measuring Tools
Session 4: Service Equipment
Session 5: Power Tool
Session 6: EVs Diagnostic Tools

Session 1: Insulated Hand Tools

Any tool that is powered by hand rather than a motor that is called hand tool. Name of some hand tools: wrenches, pliers, cutters, files, striking tools, struck or hammered tools, screwdrivers, clamps, snips, saws, drills and knives.

1 Spanner/Wrench

Spanner is a tool that provides a grip for tightening or loosening a fastener, such as a nut or bolt. Spanners are mainly used for dealing with regular fasteners such as nuts and bolts. Spanners come in different shapes and sizes and one needs to choose the type of spanner depending on its use. There are different types of spanners with different uses.

Fig. 4.1: Open-ended spanner

1.1 Open-ended spanner

Open-ended spanner has a U-shaped opening that grips the bolt or nut. This spanner is often double-ended, with a different size at each end. The ends are generally oriented at an angle of around

15 degrees to the longitudinal axis of the handle which helps maximum rotation during opening and closing of the nut or bolt.

1.2 Ring spanner

It is also used to grip the bolt or nut. It is generally a six-point or twelve-point opening for use with nuts or bolt heads with a hexagonal shape. The twelve-point fits from many angles which is an advantage where swing is limited. Eight-point wrenches are also made for square-shaped nuts and bolt heads. Ring spanners are often double-ended and usually with offset handles to improve access to the nut or bolt.

Fig.4.2: Ring spanner

1.3 Combination spanner

It is a combination of both Open-ended and ring shape. One end is with an open-ended spanner and the other end is with a ring spanner. Both ends generally fit the same size of bolt.

Fig. 4.3: Combination spanner

1.4 Adjustable spanner

This spanner is used most commonly in workshop. The adjustable end wrench differs from the monkey wrench in which the gripping faces of the jaws are displaced to a 15-degree angle relative to the tool's handle. It is used where less pressure is required.

Fig.4.4: Combination spanner

2. Ratchet

It contains a one-way mechanism which allows the socket to be turned, without removing it from the nut or bolt, simply by cycling the handle backward and forward. The photo shows both ratchet and sockets.

Fig.4.5: Ratchet

3.Pliers

Pliers are a hand tool used to hold objects firmly. Mostly, they are also useful for bending and compressing a wide range of materials. The materials used to make pliers consist mainly of steel alloys with additives such as vanadium or chromium, to improve strength and prevent corrosion. The metal handles of pliers are often fitted with grips of other materials to ensure better handling; grips are usually insulated and additionally protect against electric shock. The jaws vary widely in size, from delicate needle-nose pliers to heavy jaws capable of exerting much pressure, and shape, from basic flat jaws to various specialised and often asymmetrical jaw configurations for specific manipulations.

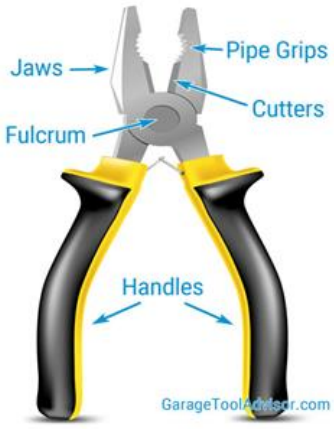


Fig.4.6: Pliers

Parts of Pliers

There are only a few parts to pliers, but all of them have an important function. In a few cases, the parts may vary to complete a specific function.

Cutters – These surfaces are generally located close to the fulcrum and are used for cutting wire and cables.

Fulcrum (or Pivot Point) – Not only is this the place where the handles and jaws connect, it also serves to create enough force for the jaws to perform their duty.

Handles – The part you hold. These can be straight or curved, and the surface will either be bare metal or plastic coated

Jaws (or Nose) – The working end of pliers are used primarily for gripping. Combination pliers have jaws which also contain cutters and/or pipe grips.

Pipe Grips – A rounded opening in the jaws, pipe grips are designed to do what the name implies, and are very useful for gripping round objects.

Types of Pliers

3.1 Combination Pliers - Pipe grip is serrated for gripping cylindrical objects, cutting or shearing off wires and cutting of soft wires.

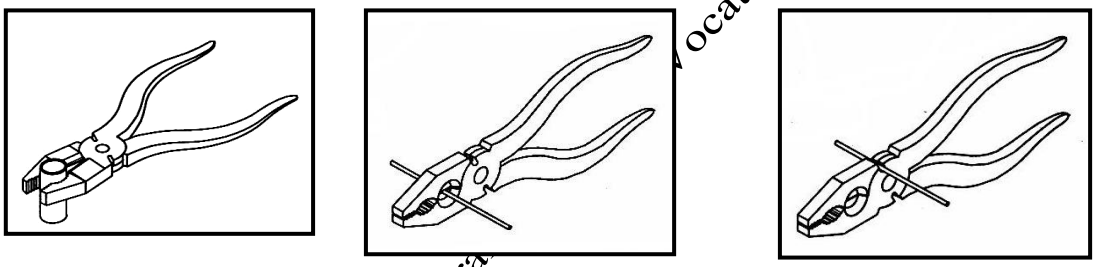


Fig.4.7: Combination Pliers

3.2 Nose Pliers - It is used for bending and folding narrow strips of thin sheet metal.

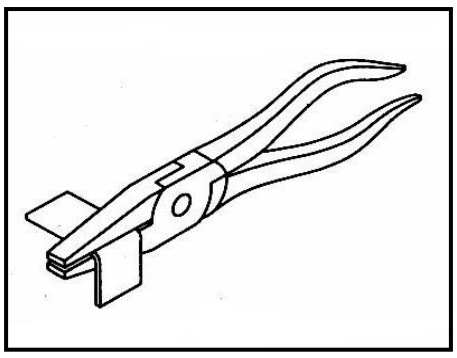


Fig.4.8: Nose Pliers

3.3 Diagonal Pliers - It is used for shearing off wires in confined spaces and cutting off wires close to the surface level.

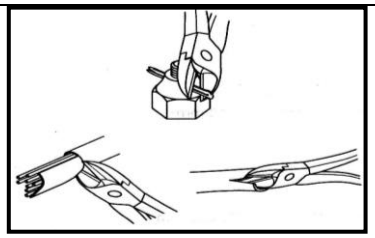


Fig.4.9: Diagonal Pliers

3.4 Pliers-round nose - It is used to shape loops in wires and to form curves in light metal strips.

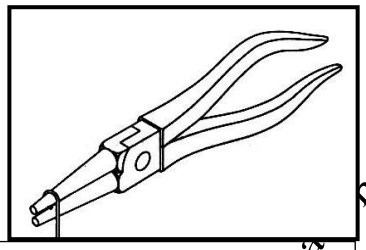


Fig.4.10: Diagonal Pliers

4. Screw Driver

It is a very useful hand tool for rotating the screws. It consists of wooden or a plastic handle and steel blade, shaped at the end. The flat end of the tool is inserted into the slot provided on the head of the screw for rotating it. Screw drivers are made in various sizes to suit the corresponding sizes of the slots on the screw heads. They should never be used to chisel, open tins, scrape off paint or lever off tight parts such as collars on shafts. Once a screwdriver blade, which is made from toughened alloy steel, has been bent, it is very difficult to keep it in the screw head.

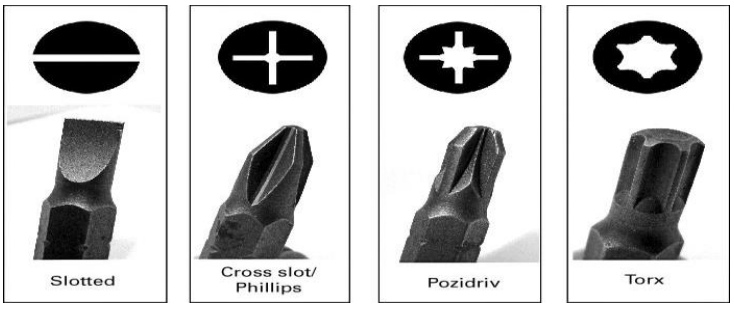


Fig. 4.11: Screw Drivers

There are a number of different head drives. The four most common are Slotted, Phillips, Pozidriv and Torx. Always select the screwdriver to suit the size and type of head drive. Use of the incorrect size or type results in damage to both the screwdriver and the screw head.

5. Vice

The Vice is the most commonly used device for clamping the workpieces to perform various operations carried out in fitting shop. There are different types of Vices available as per the requirement. For fitting workshop, following are the vices most commonly used:

1. Bench Vice
2. Leg Vice
3. Hand Vice

5.1 Bench Vice –

It is the most commonly used vice, also known as parallel jaw vice. It essentially consists of a cast steel body, a movable jaw, a fixed jaw, both made of cast steel, a handle, a square threaded screw and a nut all made of mild steel. Separate cast steel plates known as jaw plates with which the teeth are fixed to the jaws by means of set screws which can be replaced when worn. The movement of the vice is caused by the screw which passes through the nut fixed under the movable jaw. The screw is provided with a collar inside to prevent it from coming out and handle at the outer end. The width of the jaws suitable for common work varies from 80 to 140 mm and the maximum opening being 95 to 180 mm.

The height of the bench should be such that the top of the vice jaws is at about the same height as the operator's elbow.

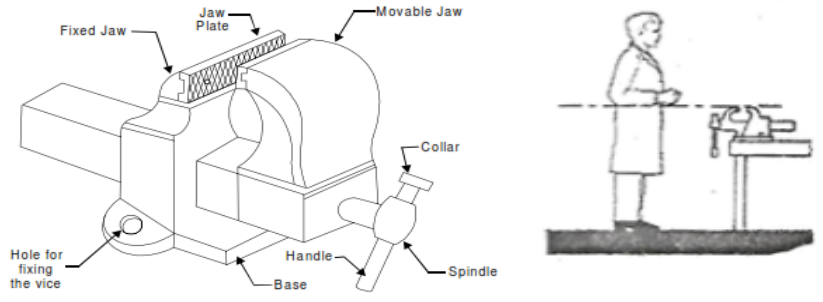


Fig. 4.12: Bench Vice

Leg Vice – Leg vice is most suitable for heavy hammering, chipping, and cutting in fitter's work. It is secured to the top of the bench and the long leg is fastened to the bench leg with staples. This construction of the vice makes

it suitable for heavy work. The main disadvantage of leg vice is that it does not provide a firm grip as in bench. Other vices (pipe vice, toolmakers vice, Hand vice, pin vice etc.) are used in workshop and tool room applications.

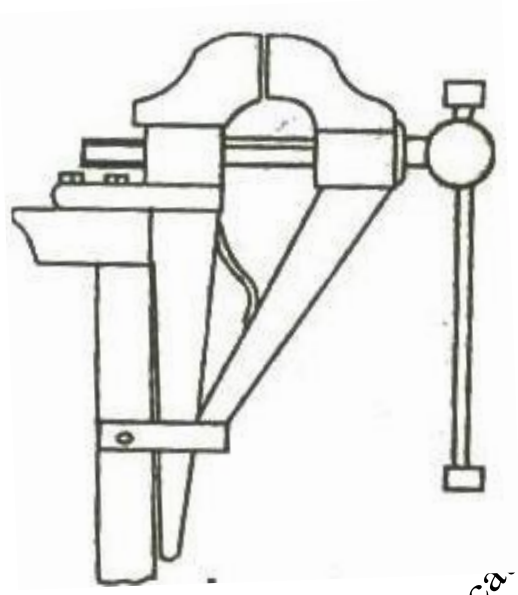


Fig. 4.13: Leg Vice

5.3 Hand Vice – Hand vice (shown in Fig. 3.14) is utilised for holding keys, small drills, screws, rivets, and other similar objects which are very small to be easily held in the bench vice. This is made in various shapes and sizes. It consists of two legs made of mild steel which hold the jaws at the top and are hinged together at the bottom. A flat spring held between the legs which tend to keep the jaws open. Its jaws can be opened and closed by a wing nut which moves through a screw that is fastened to one leg and passes through the other.

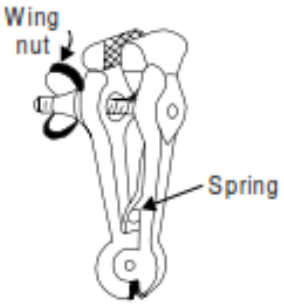


Fig. 4.14: Hand Vice

Safety during Use of Vice –

The Following points should be kept in mind while using a vice:

1. The vice should be kept clean and free from dust and metal chips using a brush.
2. The threads and the nut should be oiled regularly.
3. The vice should never be used as an anvil.
4. For holding tubes, temporary wooden blocks should be used.
5. The soft jaws should be covered with soft metal clamps when finished work is held.

C-clamp

It is most common type of clamp which is has a C-shaped frame. It is made of either forged steel or cast iron. It has an adjustable screw to assemble for jaw opening. The size of the C-clamp ranges from 3/4″ to 14″. The size of the C-clamp is measured by its jaw capacity. Jaw capacity means the dimension of the largest object the frame can cover with the screw fully opening. Generally, the jaw capacity ranges from 2” to 10”. Depth of throat is also important in C-clamp which is the distance from the center line of the screw to the inside edge of the frame. For tightening and losing the screw, cross-pin handle or a wing nut is given at the end of the screw.

Fig.4.15 (a) C-clamp

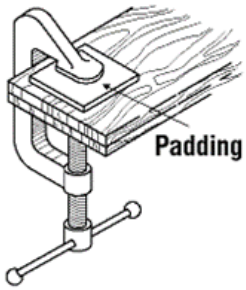


Fig.4.15 (b)C-Clamp

Safety using C-clamp:

1. Select the proper clamp style and size by matching the work-holding requirements of the job.
2. Ensure that the swivel at the end of the screw turns freely before using.
3. Dispose of clamps with bent frames; replace bent spindles, if possible.
4. Ensure that the pressure plate and anvil parts of the clamp are in full contact with the work piece before tightening.
5. Close the jaws until the clamp feels tight. For example, when gluing, some glue will be squeezed out, a sign that it is tight enough.

6. Use pads with C-clamps to avoid marking the work.
7. Remove clamps as soon as the job is finished. Clamps serve only as temporary devices for holding work securely in place.
8. Keep all moving parts of clamps lightly oiled and keep tools clean to prevent slippage. Also make sure there is no dirt or oil on any part that will come into contact with the work.
9. Store C-clamps by clamping them in a rack, not in a drawer.

Fig.4.16 Parallel Clamps

6.1 Parallel Clamps

It is also known as Hand Screw Clamp. The jaws of Clamps are made up of Steel, which is Hardened and Tempered. It is useful for holding small work together when drilling, welding, assembling etc. Clamps include spring clip and retaining ring. Mostly used by toolmakers and gunsmiths for close, precision holding of shapes for welding, brazing, scribing, drilling. Screw Heads are drilled allowing use of a pin for tightening.

7. Fasteners

Joining is one of the manufacturing processes by which two or more solid components can be assembled together to obtain a single unit. Some of these joining processes can assemble components permanently; while others can assemble temporarily. Fasteners are used to join the materials together. These are also two types - Temporary Fasteners and Permanent Fasteners.

7.1 Permanent Fasteners

Permanent fasteners are used for giving extra prevention and it also protects the infrastructure for a long term. It is basically used in buildings, storage, factories, depots, docks and various other related fields. These fasteners are very durable and are used in structures associated for human resource and also for mobile purposes. It is easy to use and can be used by any trained personnel. The permanent fasteners include welding, crimping, soldering, taping and brazing.

7.2 Temporary Fasteners

These types of fasteners are used in making provisional joints. Temporary fasteners come in various designs, shapes and sizes. It is used to join two materials for a short period of time and can be replaced in future as well. In other words, it can be called as a hardware tool to fasten objects together. It can be installed easily with the use of power tool. Temporary Fasteners include Bolts, Screws, Washers and Nuts. Bolts and nuts can be made of various materials such as steel, titanium or plastic.

8. Bolts-

Bolts are threaded fasteners comprising an outer male thread. Often bolts are confused with screws. Each of them is different and is used for different purposes. Bolts are used to create bolted joints. This is used in binding two non-threaded components.

S.	Item Name	Item View	Description
1.	Carriage Bolts		Also known as a "coach" bolt. It has a domed or countersunk head. The square section under the head grips into the part being fastened preventing the bolt from turning when the nut is tightened.
2.	Hex Head Bolts		It has hexagonal head and is driven with a wrench. It is used with nuts and washers and also driven into tapped holes.
3.	Machine Screws		It is a screw or bolt with a flat point. Available in a variety of drive types and heads, they fit a wide variety of applications. It is used with nuts and washers and also driven into tapped holes.
4.	Shoulder Bolts		These are machine screws with a shoulder between the thread of the screw and the head of the part. Once installed, the non-threaded portion extends out of the surface of the application site, allowing the bolts to act as dowels or shafts for moving parts.

5.	Socket Cap Screws		The term socket head cap screw typically refers to a type of threaded fastener in which the head diameter is nominally 1.5 times or more than that of the screw shank diameter.
6.	Socket Set "Grub" Screws		These are headless screws which mean the screw is fully threaded and has no head. A blind set screw, known in UK as a grub screw, is almost always driven with a hex Allen key. Socket set screws are installed in threaded holes or inserts.
7.	Square Head Bolts		Square Head Bolts are similar to hex cap screws but with a 4-sided head. This head style allows a wrench to grip more easily onto the head of the bolt. The head also provides a larger gripping area as compared to a standard 6-sided hexagonal head.

9. Nuts-

A nut is used along with fastening bolt to bind together multiple parts. Nuts with six faces (hexagonal) are more popular than the other types because they need just a sixth of rotation to make a rotation.

S.	Item Name	Item View	Description
1.	Cap Nut		The cap nut, also known as the acorn nut, gets its name from its shape. The nut has a domed top to prevent contact with the external thread.
2.	Castle Nuts		Used with cotter pins to prevent loosening, a castellated nut, also called a castle or slotted nut, is a nut with slots cut into the top. Used in low-torque applications such as holding a wheel bearing in place.

3.	Coupling Nuts		A coupling nut is a threaded fastener used for joining two male threads, most commonly threaded rod. The outside of the fastener is a hex so it can be driven with a wrench.
4.	Flange Serrated Nuts		A flange nut is a nut that has a wide flange at one end which acts as an integrated washer that does not move or spin. The serrated flange distributes the pressure of the nut over the part being secured and creates a locking action to prevent loosening.
5.	Slotted Hex Nuts		Slotted hex nuts are nuts with portions cut out designed to be used with a cotter ping to create a locking mechanism. These nuts are similar to a castle nut but have a lower profile which sometimes makes them a better option.
6.	Wing Nuts		Wing nuts are threaded nuts with wings on each side of the body allowing for manual turning and installation. Easy hand assembly and used when the nut needs to be removed often.

10. Screws-

Screws are a kind of bolts but have a helical ridge. Each screw consists of a head that enables it to make it fit tightly.

S.	Item Name	Item View	Description
1.	Deck Screws		It is having a notched point at the tip which is used for chip removal during thread cutting which allows for an easy installation in wood and composite deck materials.

2.	Hex Lag Screws		It is also called lag bolts. The head is external hex and are driven with a wrench. Used for lag together lumber for framing, machinery to wood floors, and other heavy-duty applications.
3.	Self-Drilling Screws		Self-drilling screws have a sheet metal thread with a self-driller cutting (TEK) point to pierce through 20 to 14-gauge metals. The higher the TEK number, the larger the drill point to pierce heavier gauge metals.
4.	Sheet Metal Screws		Sheet metal screws (SMS) have sharp cutting threads that cut into sheet metal, plastic or wood. They have a fully threaded shank and sometimes have a notched point at the tip to aid in chip removal during thread cutting.

11. Washers-

Washers spread the load over a greater surface area when tightening a bolt, screw or nut. Lock washers help preventing loosening.

Fig. 4.17: Washers

Check Your Progress

A. Fill in the Blanks:

1. A _____ is a hand tool used for turning screws to fasten or loosen them.
2. A wrench, also known as a _____, is a hand tool used for gripping and turning nuts, bolts, or other fasteners.
3. _____ are hand tools with two handles and a pair of jaws used for gripping, bending, cutting, and holding objects.
4. A _____ is a hand tool consisting of a handle and a hardened steel bar with a series of parallel ridges or teeth

B. Multiple Choice Questions:

1. What is a hand tool?
a) A tool powered by electricity
b) A tool operated by hand
c) A tool operated by foot
d) A tool operated by voice

2. Which of the following is a hand tool used for tightening or loosening nuts or bolts?
a) Pliers
b) Cutters
c) Wrench
d) Hammer

3. Which type of wrench has a U-shaped opening that grips the Bolt or Nut?
a) Open-ended spanner
b) Ring spanner
c) Combination spanner
d) Adjustable spanner

4. What is a tool that contains a one-way mechanism allowing the socket to be turned without removing it from the nut or bolt?
a) Ratchet
b) Screwdriver
c) Pliers
d) Vice

C. ANSWER THE FOLLOWING QUESTIONS:

1. Explain the concept of hand tools and provide examples.
2. What are pliers and what are the various types of pliers? Explain their functions.
3. Discuss the uses of screwdrivers and the different types of screwdrivers.
4. Explain the purpose of vices and provide information on different types of vices.
5. What is a C-clamp, and what safety measures should be followed while using it?

Activity

1. Create a table with picture cards or descriptions of different hand tools and match each tool with its corresponding name or function.

Session 2: Insulated Hand Cutting Tools

Introduction

Hand Cutting tools are used to remove small amounts of material, usually from small areas of the work piece. This may be done where it is difficult to do machining, the work piece is too large to go on a machine, the shape is too intricate or simply that it would be too expensive to set up a machine to do the work. The use of hand tools is physically tiring, it is important that the amount of material to be removed by hand is kept to an absolute minimum and that a correct tool is chosen for the task. Wherever possible, try to use powered hand tools, not only to reduce fatigue but also to increase the speed of the operation and so to reduce the cost.

2.1 – Chisel

Chisel is one of the most important tools of the sheet metal, fitting and forging shop. It is widely used for cutting and chipping the work piece. They are made from High-Carbon steel, hardened and tempered at the cutting end. Full length of the chisel is never hardened, only a small length about the cutting edge (say about 20 to 30 mm) is hardened. The length of the chisel is about 150mm to 200mm. When the cutting edge becomes blunt, it is again sharpened by grinding.

There are many verities of chisels used for chipping work by a fitter. Some very commonly used forms are Flat, Cross-cut, Round nose and Diamond point. All the chisels are forged from bar stock of Carbon steel, to the desired shape and the cutting-edge ground to the correct angle. The angle of the cutting edge of the chisel is 35°-70°according to the metals to be cut.

Types of Chisels:

There are four types of chisels used in fitting work, these are: -

1. **Flat Chisel**

A flat chisel is a general-purpose chisel which is most widely used in cutting work, chipping large surface, cutting metal sheets, rods, bar stocks and similar other purposes. Since it cuts the metal in cold state it is also frequently known as cold chisel.

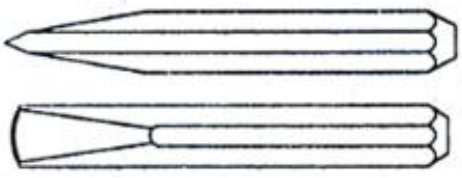


Fig.4.18: Flat Chisel

2. Cross Cut Chisel

A cross cut is a comparatively narrow chisel having its cutting edge slightly broader than the blade. It is made to keep the blade free when the chisel is used to cut a deep groove into the metal. Normal widths of the cutting edge vary from 3 mm to 12 mm. This chisel is used to cut parallel grooves on large surfaces, before chipping by means of a flat chisel, cutting key ways, etc.

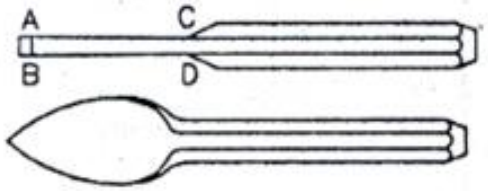


Fig.4.19: Cross Cut Chisel

3.Half-Round Chisel

A round nose chisel is used for drawing the eccentric hold back to correct centre which has run off-centre during drilling operation. Another specific use of this type of chisel is in cutting oil grooves and channels in bearings and pulley bushes and cleaning small round corners.

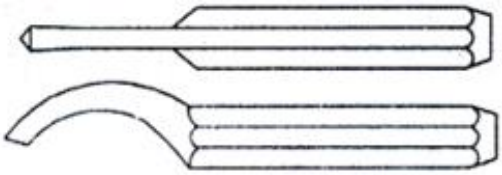


Fig.4.20: Half-Round Chisel

4.Diamond Point Chisel

A diamond point chisel is a special purpose chisel used for chipping rough plates and cutting cast iron pipes, cutting 'V' grooves, chipping sharp corners, squaring up corners of previously cut slots and cleaning angles.

Application of Chisel

For cutting the job or work piece with the chisel, it is placed vertically on the job or work piece and hammering is carried out upon its head.

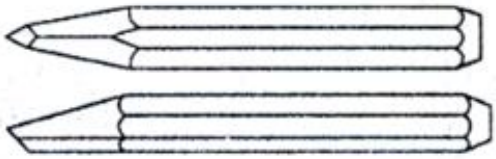


Fig. 4.21: Diamond Point Chisel

But for chipping, the chisel is inclined at 40°-70° with the job or work piece.

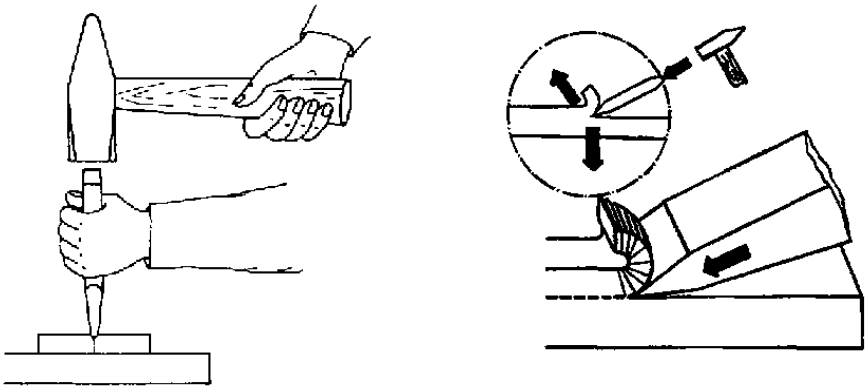


Fig.4.22: Application of Diamond Point Chisel

2.2 – Hacksaw

The hand hacksaw is used to cut metal like bar stocks, rods, tubes, iron flats and metal sheets, etc but it is not used for cutting hardened steel. It is used to remove large amounts of waste metal which is more easily done rather than by filing. It consists of a metal frame, fitted with a wooden handle, carrying metal clips with wing-nut at its end to hold. The clip carrying the wing nut is threaded to stretch the blade to the desired extent. The frame can be either of fixed type, which can accommodate the same length of blades or adjustable type which is capable of accommodating different lengths of blades.

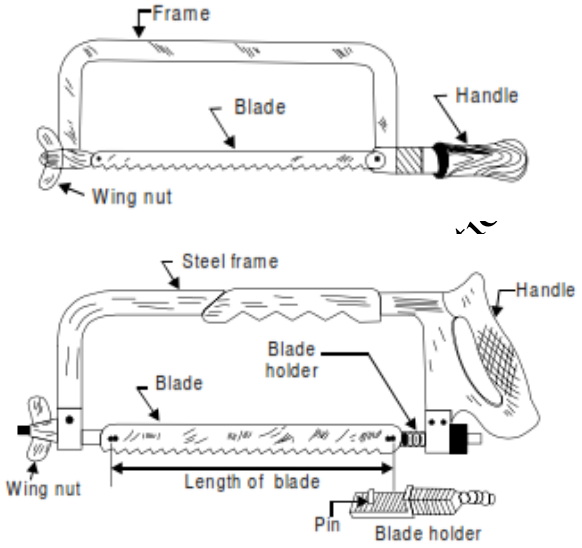
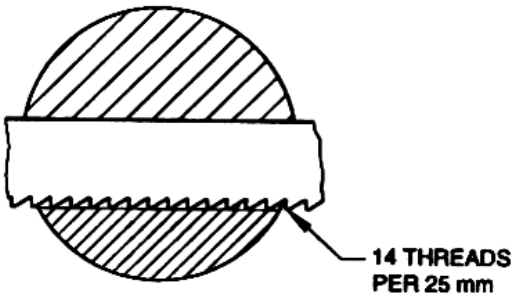


Fig.4.23: Hackshaw

Hacksaw Blade

Hack saw blades are made of high Carbon steel or low alloy steel. Hack saw blade is the main part. Push type blades, those which cut in forward stroke only, are generally used. The blades in common use are generally 0.7 mm thick, 12.7 mm wide and 20 cm to 30 cm long. The selection of the blade depends on the shape and hardness of the material to be cut. Following are the three types of Hachsaw Blade :-

1. For soft materials such as bronze, brass, soft steel, cast iron, heavy angles etc. use a 1.8 mm pitch (14 threads per 25 mm) blade.



2. For tool steel, high Carbon, etc. use a 1.4 mm pitch (18 threads per25 mm). For angle iron, brass tubing, copper, iron pipe etc. use a 1 mm pitch (24 threads per 25 mm) blade.
3. For conduit and other thin tubing, sheet metal work etc. use a 0.8 mm pitch (32 threads per 25 mm).

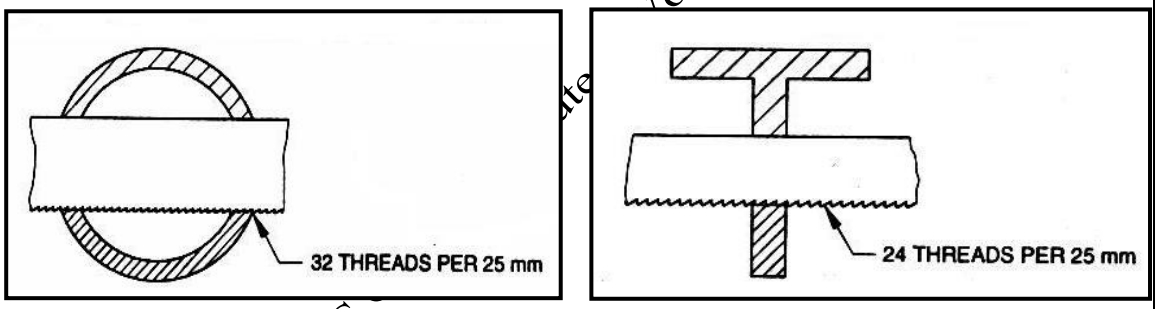
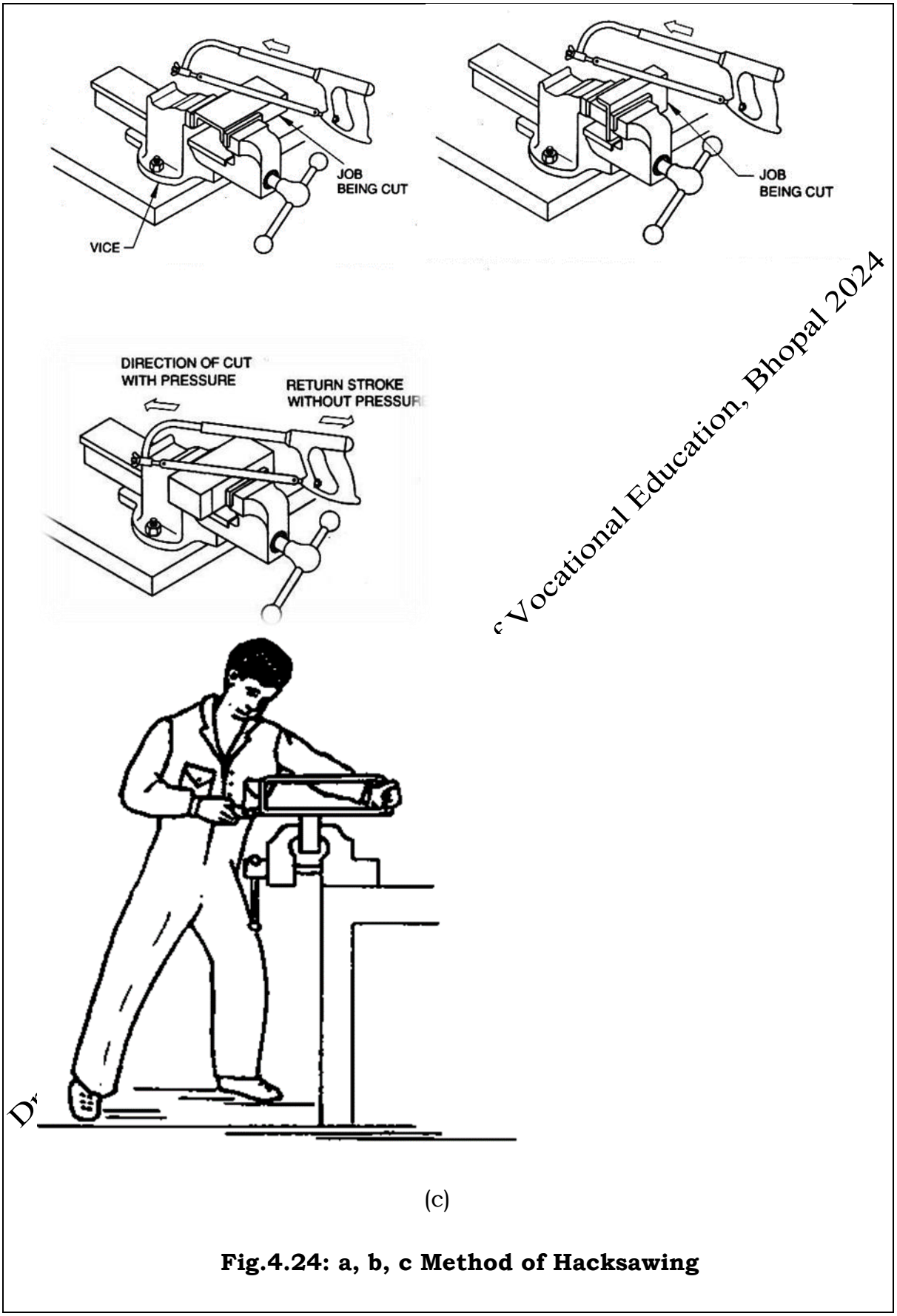


Fig.4.24: Hacksaw Blade

Method Of Hacksawing

- Position the job to be cut according to the cross-section for hacksawing.
- As far as possible, the job is to be held so as to be cut on the flat side rather than the edge or the corner. This reduces the blade breakage.
- Before beginning to saw make sure that the height of the vice is correct and that the workpiece is firmly clamped!
- The weight of the body is resting on one leg while the other leg is always straightened with both feet firmly on the ground.
- The saw is moved with the arms and such movement may be slightly supported by the upper part of the body.



(c)

Fig.4.24: a, b, c Method of Hacksawing

- When pushing the saw is pressed onto the workpiece, pulling back is without exerting any pressure.
- The total length of the saw blade is to be utilised when sawing.
- Cutting oil is to be slightly applied to the sides of the sawing blade before use to minimise friction.

Safety and Care of Hacksaw

1. The cutting action is carried on the forward action only. So the blade must be mounted with its teeth pointing forward.
2. Suitable tension should be applied on the blade to avoid breakage or loosening.
3. Change the blade if some teeth are broken.
4. Avoid rapid and erratic strokes of cut.
5. Avoid too much pressure.
6. Work piece must be held firmly.

2.4 – Files

A file is a cutting tool with multiple cutting edges used for filing. It is used to remove the material by rubbing it on the metals. They can be obtained in a variety of shapes and in lengths from 150 mm to 350 mm. When a file has a single series of teeth cut across its face it is known as single-cut file, and with two sets of teeth cut across its face it is known as double-cut file.

Parts of File

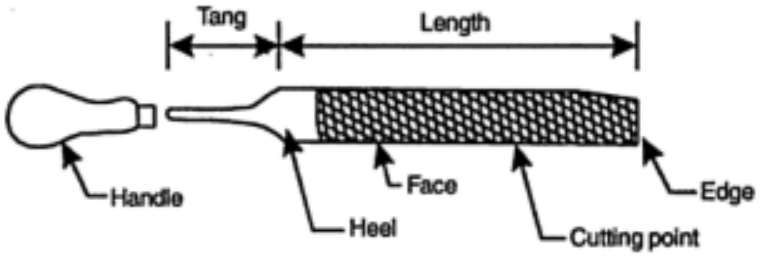


Fig. 4.25: Files

- **Tip or Point** - This is the end of the file opposite to tang.
- **Face or side** - The broad part of the file with teeth cut on it.
- **Edge** - The thin part of the file with simple row of parallel teeth.
- **Heel** - It is the broad part of the file without teeth.

- **Shoulder -** It is the curved part of the file separating the tang from the body.
- **Tang -** It is the narrow and thin part of a file which fits into the handle.
- **Handle -** It is the part fitted to the tang to hold and use the file.

File Specifications and Grades

Files are manufactured in different types and grades to meet the various needs. Files are specified according to Length, Grade, Cut, and Shape.

Length - Length is the distance from the tip of a file to the heel.

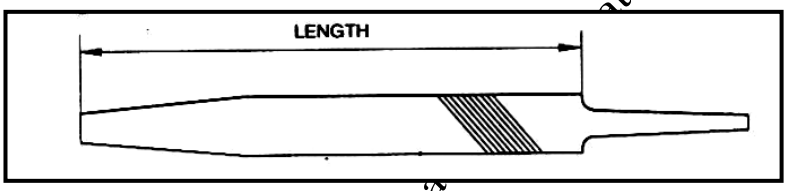


Fig. 4.26: File Length

Grades of files - File grades are determined by the number of teeth per Sq.cm. area. Different sizes of files with the same grade will have varying sizes of teeth. In longer files, the teeth will be coarser.

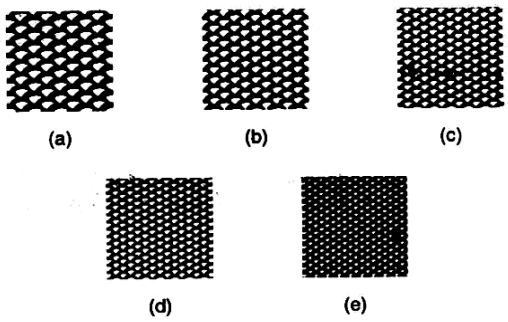


Fig. 4.27: Grades of files

A rough file is used for removing rapidly a larger quantity of metal. It is mostly used for trimming the rough edges of soft material castings.

(a) A bastard file is used in cases where there is a heavy reduction of material.

(b) A second cut file is used to give a good finish on metals. It is excellent to file hard metals. It is useful for bringing the jobs close to the finishing size.

(c) A smooth file is used to remove small quantity of material and to give a good finish.
(d) A dead smooth file is used to bring to accurate size with a high degree of finish.

The most used grades of files are bastard, second cut and dead smooth. These are the grades recommended by the Bureau of Indian Standards (BIS).

Cut - The teeth of a file are formed by cuts made on its face. Files have cuts of different types. Files with different cuts have different uses.

Types of Cuts

Basically, there are four types i.e., Single cut, Double cut, Rasp cut and Curved cut.

Single cut file - A single cut file has rows of teeth cut in one direction across its face. The teeth are at an angle of 60 degrees to the centre line. It can cut chips as wide as the cut of the file. Files with this cut are useful for filling soft metals like brass, aluminium, bronze and copper. Single cut files do not remove stock as fast as double cut files, but the finish obtained is much smoother.

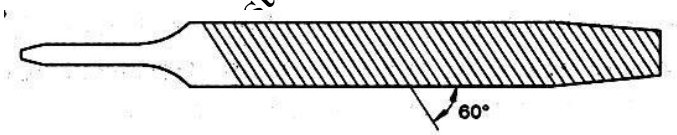


Fig. 4.28: Single cut file

Double cut file - A double cut file has two rows of teeth cut diagonal to each other. The first row of teeth is known as OVERCUT and they are cut at an angle of 70 degrees. The other cut, made diagonal to this is known as UP CUT, and is at an angle of 51°. This removes stock faster than the single cut file.

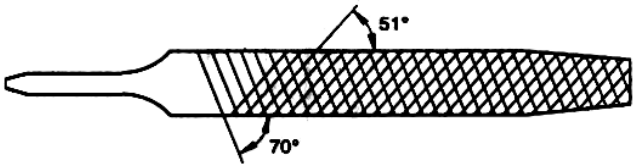


Fig. 4.29: Double cut file

Rasp cut and curved cut files - Rasp cut files are used for filing wood and other soft material, while curved cut files are used for filing aluminium, tin, copper and plastic.

Shape

The various shapes of files with their application is shown below. The cross-section drawn in the file refers to the shape of the file.

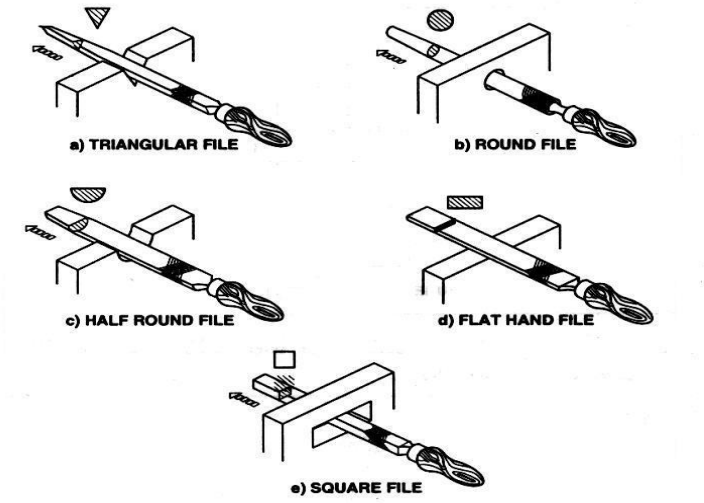


Fig. 4.30: Rasp cut and curved cut files

Care of flies: -

The following points should be considered while using files.

1) The file should not be used without handle or with loose fitting handle.
2) File should never be used on hardened steel or hard surface.
3) New file should be used first on copper, brass and then on wrought Iron and mild steel.
4) The file should not be allowed to rust, and to prevent it, the tile must be coated with machine oil. Before using the file, the oil should be removed with Carbon tetrachloride or caustic soda.
5) The worn-out files may be reused by dipping it in hydrochloric acid.

Filing

There are two types of filing commonly used to remove the materials i.e. Cross Filling and Draw Filing.

Cross Filing - Moving the file diagonally on a flat surface always yields the best results. A coarse-pitched file should be employed when enough metal is to be removed, followed by finishing with a smooth file. As far as possible, try to use the full length of the file during the operation. The pressure of the hand in filing should also be applied only during the forward stroke and relieved during the return stroke.

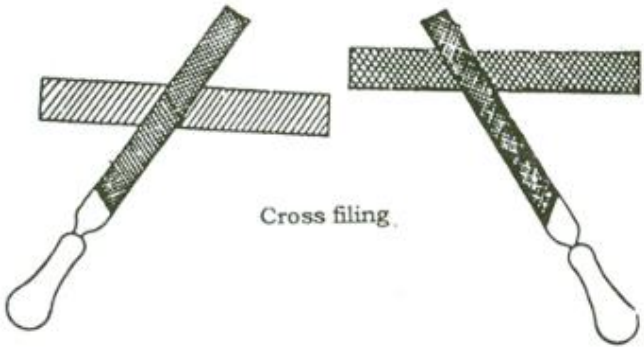


Fig. 4.31: Filing

Straight Filing - In straight-filing the file is pressed forward approximately at right angles to the length of work. On the back stroke, the file should be lifted clear of the work in order not to blunt the teeth. Straight-filing is specially used on long and narrow piece of work which has a width is lesser than that of the file.

Draw Filing - When the surface is to be finally finished by filing only and no other operation, like scraping, is to be followed by the filing operation, a special method of filing, called Draw filing, is employed for finishing the surface. A flat file of fine cut is used for this operation. For draw filing operation the file is held flat on the surface between the two hands. The file must move forward and backward. Flatness and evenness of the surface should be checked quite frequently during the operation.

Fig. 4.32: Straight Filing

File Card

It is a device designed like a wire brush used in cleaning dirt and chips from the teeth of a file. When particles of metal clog the teeth, the file is said to be pinned, a condition that causes scratching of the surface of the work. The pinning can be removed with a File Card, which is a wire brush mounted on a block of wood. Sweep the file card along the grooves on the file until the pinning is removed.

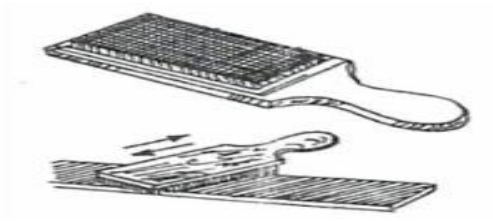


Fig. 4.33: File Card

Check Your Progress

A. Fill in the Blanks:

1. Hand cutting tools are used for Removing _____.
2. The purpose of using powered hand tools is to increase speed, _____ fatigue and cost.
3. The length of a chisels vary from _____ to _____.
4. The purpose of a file card is to _____ and _____.

B. Multiple Choice Questions:

1. Which of the following is NOT a reason for using hand cutting tools?
a) Difficult to do machining
b) Workpiece is too large for machines
c) Shape is too intricate
d) Cost-effective to set up a machine

2. Chisels are made from:
a) Aluminum
b) Stainless steel
c) High-Carbon steel
d) Cast iron

3. What is the purpose of a single-cut file?
a) Filing wood

b) Filing aluminum
c) Filing soft metals
d) Filing hardened steel

4. Which type of filing is employed for finishing the surface when no other operation follows?
a) Cross filing
b) Straight filing
c) Draw filing
d) Rasp filing

Answer the Following Questions:

1. What is hand cutting tools, and why are they used in certain situations?
2. Discuss the method of hacksawing, including the positioning of the job, body posture, and cutting techniques.
3. Define a file and its purpose. Explain the different parts of a file and their functions.
4. What are the necessary precautions and maintenance procedures for using files effectively?

Activity

Collect images or actual samples of different hand cutting tools, such as chisels, hacksaws, and files. Identify and name each tool correctly.
Create a poster or infographic that highlights the essential safety measures when working with these tools. Display the posters in the classroom as a reminder for safe tool usage.

Session 3: Measuring Tool

Multimeter

This is an Electronic testing equipment that helps in the diagnosis of various faults in the electrical system of a two-wheeler. Multimeters can be diagnosed through

- Resistance values of coils – Lighting/Charging/source/pulsar/ignition coils
- Continuity of wires, switches and coils
- DC Voltages of Battery, RR (Charging system)
- AC voltages of RR... etc (AC Lighting System)
- Temperature range

Fig. 4.34: Multimeter

Do's and Don'ts in Multimeter: -

The Multimeter is a sensitive Equipment that has to be handled very carefully for a long period of trouble-free life and accurate readings.

- Check for Zero error of readings in 200 Ohms mode before using the meter.
- Select the appropriate mode for the particular measurement.
- Do not turn the selector knob rapidly, Turn it step by step.
- Switch off the ignition key whenever you are using resistance mode.
- Switch off the multimeter when not in use to prevent battery draining.
- It is better to check the resistance of wires rather than continuity.

Vernier Caliper: -

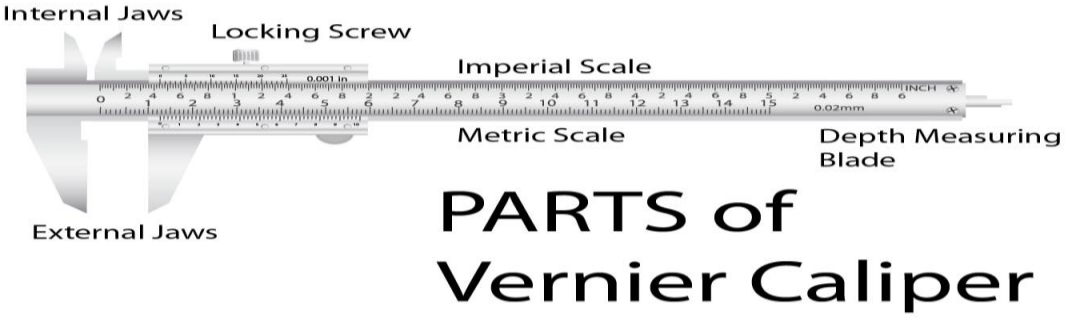


Fig. 4.35: Vernier Caliper

The Vernier Caliper is a very convenient measuring instrument for making outside, inside and depth measurement. As shown in figure. Three types of measurements can be made by using different parts of the Vernier Caliper

A. Outside measurement B. Inside measurement C. Depth measurement

Least count: -

Least count is the smallest measurement that can measured in a Vernier Caliper.

Least count = Smallest division on main scale of division on Vernier scale

Smallest division on main scale = 1 mm of division on Vernier scale = 50 Lest count = 1/50

= 0.02 mm

Step 1:

As Zero graduation on the Vernier scale is between 12 mm and 13 mm on the main scale, the reading is 12 mm.

Step 2:

As graduation '5' on the Vernier scale happens to coincide with a graduation on the main scale, the reading is 0.5mm.

Step 3:

Add both step 1 and step 2.

Step 1: 12mm, Step 2: 0.5mm, Total:12.5 mm

Thus, the reading is 12.5mm

Micrometer:

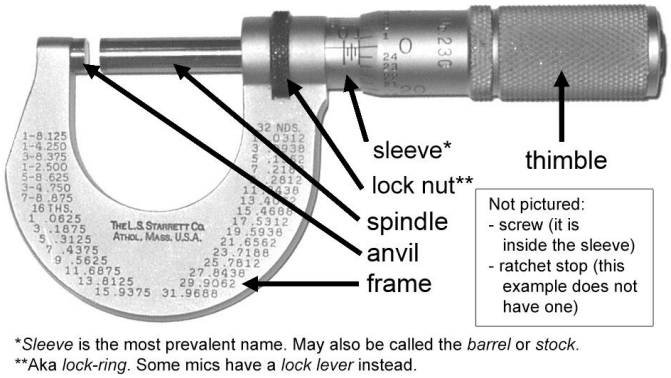


Fig. 4.36: Micrometer

The Micrometer is used to obtain higher precise measurement than those the Vernier calliper can provide. There are also various types of the Micrometer depending upon its applicability. Two basic types among them are:

Outside Micrometer and Inside Micrometer

Least count: -

Least count is the smallest measurement that can be measured in a Micrometer.

Least count = Pitch / of divisions on Micrometer thimble

Example,

Pitch is the distance travelled by thimble on linear scale in one rotation which is 0.5mm of division on Micrometer thimble = 50

Least count = 0.5/50

= 0.01 mm

Step 1:

As the thimble has uncovered 13 mm, the reading is 13 mm.

Step 2:

See if the thimble has also uncovered 0.5mm graduation adjacent to 13 mm. if it has, as in this case, the reading in this step is 0.5mm. And if it hasn't, the reading is 0.00mm

Step 3:

Read off the graduation on the thimble which coincides with the graduation line on the sleeve. The reading in this step 4.

Step 4:

Add the reading obtained in steps 1,2 and 3.

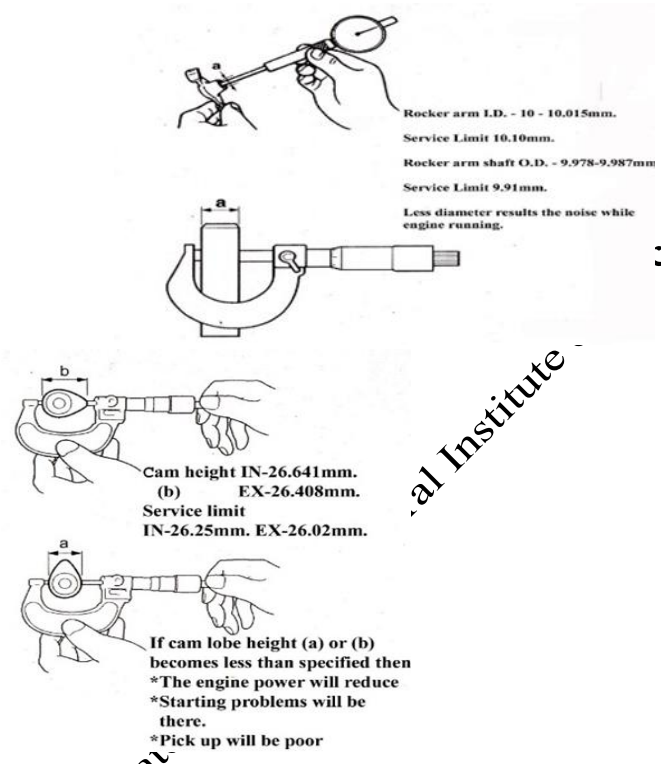


Fig. 4.37: Reading obtained in steps

Step 1	:	13
Step 2	:	0.5
Step 3	:	0.4
Total	:	13.92

Dial gauge:

The dial gauge is a measuring instrument which, in its structure, responds to every moment of the spindle, magnifies it mechanically and converts it into the movement of the pointer, thus is capable of accurate measurement.

Fig. 4.38: Dial gauge

The Least count of the dial gauge is 0.01mm.

Before measuring with a dial gauge it should be fixed firmly. For that purpose, use a magnetic stand and set it on an iron plane avoiding any curved face.

When setting up the dial gauge on the work. Push the spindle against the work so that the pointer makes at least half a revolution. How much it is pushed depends on how much the work is distorted. Therefore, that must be decided in every case so that the spindle can follow the work. After setting up the dial gauge, make the pointer and zero, on the dial face, coincide by turning the bezel. After setting the pointer to zero graduation on the dial face turn the work gently, and the pointer will deflect clockwise and counter clockwise. The maximum deflection in both directions will be the reading.

Torque wrench: -

The torque wrench is a tool used to tighten bolts, nuts, etc. to the specified torque.

A specified torque can be set by pulling the adjuster knob out and rotating it clock wise. Socket adaptor can be pushed to the other end for LH threaded fasteners. Fasteners should not be further tightened after hearing the tock sound from the ratchet. Torque wrench should not be used for loosening of any fasteners. To set at 25 NM rotate the adjuster knob till the handle reaches 25 NM mark.

Fig. 4.39: Torque wrench

Feeler gauge: -

The feeler gauge is a set of iron blades of different thickness. Thus, the thickness gauge serves to measure valve clearance, a point gap, connecting rod big end thrust clearance, a clearance between a piston ring and groove, etc. As there are various types of thickness gauge available, select the one as per the specification given.

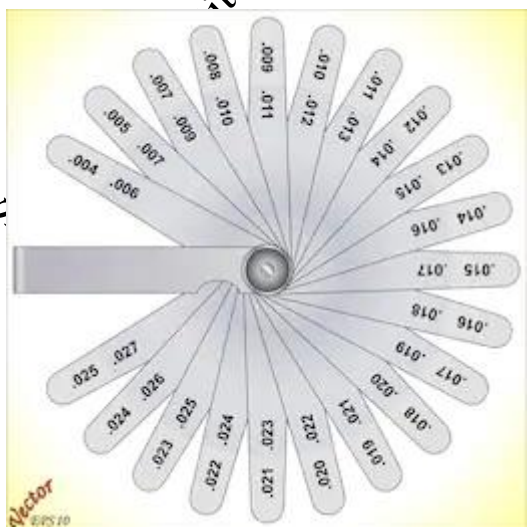


Fig. 4.40: Feeler gauge

Setting of Valve clearance

It is very essential to ensure that the valves are closed fully during the closing period of cam. The valve clearance should be adjusted properly to achieve this and cater for certain amount of thermal expansion of the working component

Special tools for High Voltage System

In addition to common hand tools, HV systems also require specialty tools for reading the power of the battery and the system in volts and amps. These tools are not only designed to be insulated from high-voltage, they're designed to safely have high-voltage and amperage run through them. Just like the hand tools, these electrical testers and meters need to be handled with care – not only to ensure proper functionality but to minimise the risk of compromising the tool's insulative properties and increasing the risk of deadly electric shock.

DIGITAL VOLT OHM METER

An HV DIGITAL VOLT OHM METER (DVOM) is likely the most common tool that will be used with an HV system. As the name implies, this meter is designed for HV applications and typically can handle up to 1,000 volts. Attempting to use a standard DVOM on an HV system will almost undoubtedly have disastrous results. In addition to the risk of deadly electrocution, the DVOM will almost assuredly be destroyed.

Electrical measurement tools are categorised at different levels, from CAT I to IV. The following are brief explanations of each level:

CAT I. Category I is for measurements performed on circuits not directly connected to mains. Examples are measurements on circuits not derived from mains and specially protected (internal) mains-derived circuits.

CAT II. Measurement category II is for measurements performed on circuits directly connected to the low-voltage installation. Examples are measurements on household appliances, portable tools and similar equipment

CAT III. Measurement category III is for measurements performed in the building installation. Examples are measurements on distribution boards, circuit-breakers, wiring (including cables), bus bars, junction boxes, switches, socket-outlets in the fixed installation, and equipment for industries.

CAT IV. Measurement category IV is for measurements performed at the source of the low-voltage installation. Examples are electricity meters and measurements on primary overcurrent protection devices and ripple control units

For HV measurement purposes, a minimum of a CAT III meter is required. However, the use of CAT IV is preferred as it adds a better layer of protection when working on a high-voltage system.

Proper Usage

Having the right tool and using it correctly are two different things. Other than the safety factor of using the HV-DVOM correctly, it is necessary to know how to obtain proper readings. Testing the meter on a known low-voltage source, such as the vehicle's 12-volt battery, is the first step. This allows the technician to verify not only the proper use of the tool but tool accuracy as well.

Faulty meters or leads can produce a false "zero voltage" reading. You're better off discovering an issue with low-voltage than with high-voltage. Because the HV system circuits are isolated from the vehicle chassis ground, the leads must take readings directly from the HV connections. OEMs will typically provide information on where to measure. Depending on the work that is being performed, the locations to measure may be HV cable ends, connectors or the battery itself.

TWO POLE VOLTAGE METERS: -

As the name implies, this tool measures only voltage. Unlike a DVOM, this tool is not dependent on an internal battery to perform its functions. This means that there is no failure to read or reading inaccuracy that can occur due to a low or dead internal battery. In addition, unlike the DVOM, there are no settings to adjust or select. This eliminates the potential of having the meter on the wrong setting. Just as with the HV-DVOM, it is a good idea to test the two-pole voltage meter on a known low-voltage source. These meters will often have a function that will allow the technician to simply press a button or buttons on the tester to place a slight load on the circuit, allowing any residual or "ghost" voltage remaining in the circuit after isolation or disconnection to be dissipated. It is important to note that this feature is not designed to discharge a capacitor.

Fig. 4.41: Two Pole Voltage Meter

Testing for Voltage

When testing for voltage on an HV system, a good practice is to not only test for voltage between HV+ and HV- but to also test for HV+ to vehicle ground and HV- to vehicle ground (chassis). This helps to identify any potential faults in the HV system that have allowed the high-voltage to break containment and now be flowing through the vehicle chassis. This is important as the possibility of this voltage breach is heightened in the event of a collision but can also occur due to chaffing, chemical deterioration or cuts that compromise the HV wiring insulation.

Once you've confirmed your voltage with the three-step process, there is still one more step. Take your DVOM or two-pole voltage meter and go back to the same low-voltage source you tested on and take another reading. This is another safety step that helps ensure that there was not an error with the function of the tool when testing the HV system.

MILLIOHM METER

Another tool that is needed for HV systems is a milliohm meter, which will measure very small amounts of electrical resistance. A milliohm is 1/1000th of an ohm.

Measuring such a small amount of electrical resistance is accomplished by two probes that each have two terminals. One of the terminals on each probe provides an electrical charge of typically one amp. The other terminal on each probe reads voltage. This allows the tool to determine the resistance in ohms by applying ohms' law, which has an exact and constant relationship between volts, amps and ohms. The tool calculates this quickly and accurately.

With an HV system, due to the high number of volts and amps, even the smallest resistance in the wiring or components of the system is going to cause issues. Being able to accurately identify and read these small amounts of resistance is imperative and is something a standard ohm meter or DVOM simply cannot do. Accurate measurement in milliohms is important to measure bonding of an HV component to the chassis. Only a good bonding allows the insulation guard in the CU to detect insulation arrows.

Check Your Progress

A. Fill in the Blanks:

1..... Is electronic testing equipment that helps in the diagnosis of various faults in an electrical system of a two-wheeler.

2. Check for Zero error of readings in ..... mode before using the meter.

3. The Vernier Caliper is a very convenient measuring instrument for making .....and .....measurement.

4. Valve spring Measures the free length of the .....and..... springs.

B. Multiple Choice Questions:

1. What is the primary purpose of a multimeters?

a) To measure the temperature range of a two-wheeler

b) To diagnose faults in the electrical system of a two-wheeler

c) To measure the resistance of wires and switches

d) To measure the DC and AC voltages of a two-wheeler's battery and lighting system

2. What is the primary purpose of a Vernier Caliper?

a) To measure outside, inside, and depth measurements

b) To measure the temperature range of a two-wheeler

c) To measure the resistance of wires and switches

d) To measure the DC and AC voltages of a two-wheeler's battery and lighting system

3. What is the primary purpose of a Micrometer?
   a) To measure outside, inside, and depth measurements
   b) To measure the temperature range of a two-wheeler
   c) To measure the resistance of wires and switches
   d) To obtain higher precise measurements than a Vernier Caliper

4. What is the primary purpose of a dial gauge?
   a) To measure outside, inside, and depth measurements
   b) To measure the temperature range of a two-wheeler
   c) To measure accurate movements and deflections
   d) To tighten bolts and nuts to specified torque

5. What is the primary purpose of a torque wrench?
   a) To measure outside, inside, and depth measurements
   b) To measure the temperature range of a two-wheeler
   c) To measure accurate movements and deflections
   d) To tighten bolts and nuts to specified torque

2. Answer the following questions:

1. What is the primary purpose of a multimeters and how does it contribute to diagnosing faults in the electrical system of a two-wheeler?
2. What are the various measurements that can be performed using a multimeter and how do they aid in assessing the condition of a two-wheeler's electrical components?
3. How does a Vernier calliper facilitate measurements of outside, inside, and depth dimensions, and what are its practical applications in the context of two-wheelers?
4. How does a dial gauge function in accurately measuring movements and deflections, and what are its specific applications in various industries, including two-wheeler maintenance?
5. What is the primary purpose of a torque wrench, and how does it ensure the proper tightening of bolts and nuts to specific torque values, particularly in the context of two-wheeler maintenance?

Activity

1. Identify and label different insulated tools.
2. Perform the practical work in the lab using measuring tools such as a Micrometer, Vernier Caliper (Internal and outer), Feeler Gauge, and Dial Gauge.

Session 4: Service Equipment

It has becoming even more important to consider what you need for servicing Electric Vehicles. There are considerations to be take when looking to gear-up towards Electric Vehicle servicing:

- Vehicle lift
- Wider than normal
- Clear floor
- Low profile arms - avoid scissor lifts
- Supplemental vehicle securing by means of straps recommended when removing significant loads from a vehicle

Ensure that the lift provides the greatest amount of access to the underside of a vehicle.

Non-metal workbench: - It's dangerous to put high voltage parts on anything metal, so a sturdy workbench made of hardwood or plywood can be a good option. Wood is non-conductive and provides a stable surface for working on Electric Vehicles. Make sure the wood is properly treated to resist moisture and damage. If you don't want to purchase new workbenches, you could cover your existing benches with thick rubber floor mats or large mud flaps.

Service Equipment

This equipment in used for repairing, routine check-up and to modify the system we use. It may include routine upkeep as well as corrective repair work. Equipment may include mechanical assets, tools, heavy off-road vehicles, and computer systems.

Motorcycle Ramp

1. Inspect the hydraulic connections for leakage, and tighten them if required.
2. Lubricate the ramp roller, rail and Pivots.

3. Regularly clean the ramp cylinder piston's outer surface and check for leakage.
4. Replace the oil seals if found leakage.
5. Always use ramp lock for safe operation and to save the hydraulic cylinder from leakage.
6. Regular paint touch-ups to prevent rusting.

Fig. 4.42: Two-Wheeler Ramp

Maintenance Tips

- Remove the rust from the terminals and coat with petroleum jelly.

Precautions Maintenance:

- Wash the battery with soap and water before installing on the charger to save from acid spillage.
- Never connect the terminals in reverse.
- Always connect battery's red wire to red connector on the charger.
- Disconnect the power supply when not in use.
- Always place the battery charger in a ventilated area.
- Clean Terminals, No Reverse Connections, Clean the battery before installation

Battery Lifting Tables:

A key addition to a workshop with an Electric Vehicle Bay will be a lifting table. With battery maintenance being a key part of the service of an Electric Vehicle, due to the battery being the largest and most expensive single component. A robust lift table for battery management will be required. There are several markets ranging significantly in price depending upon whether you want manual operation, electric operation, your capacity requirements, lift speed and lifting height considerations, as well as key Health and Safety considerations.

Tyre and Wheel Equipment:

Whilst the requirements for tyre and wheel equipment on Electric Vehicles are no different than Petrol and Diesel vehicles, it is important to consider that because electric cars weigh 20-30% more and usually deliver significantly more torque, this has an impact on tyre wear. Therefore, tyre sales and fittings play a significant part in EV vehicle support.

Battery Charger

A charging station sends electromagnetic energy through inductive coupling to an electrical device, which stores the energy in the batteries. This is achieved without the need for metal contacts between the charger and the battery.

Fig. 4.43: Battery Charger

Check Your Progress

A. Fill in the Blanks:

1. _____ workbench made of hardwood or plywood, is recommended for working on Electric Vehicles.
2. _____ is a key part of servicing Electric Vehicles, and a lifting table is required for battery management.
3. Electric cars weigh 20-30% more and deliver more torque, resulting in increased _____.

B. Multiple Choice Questions:

1. What are the recommended considerations for vehicle lifts when gearing up towards Electric Vehicle servicing?

a) Wider than normal
b) Clear floor
c) Low profile arms
d) All of the above

2. Why is a non-metal workbench recommended for servicing Electric Vehicles?
a) It provides a stable surface for working on Electric Vehicles.
b) Wood is non-conductive.
c) High voltage parts can be dangerous when placed on metal.
d) All of the above

3. What is one precaution recommended for battery maintenance?
a) Wash the battery with soap and water before installing it on the charger.
b) Always connect battery's red wire to red connector on the charger.
c) Disconnect the power supply when not in use.
d) Place the battery charger in a ventilated area.

C. Answer the following Questions

1. What precautions should be taken during battery maintenance?
2. Describe the role of a charging station in Electric Vehicle battery charging.
3. Explain the key considerations for battery lifting tables in an Electric Vehicle workshop.
4. Describe the precautions to be taken during battery maintenance.

Activity

1. Prepare a list of materials used in workshop.
2. List the activities needed to be performed for preparing an EV for fault identification and repairing work.

Session 5: Power Tool

A tool is an object used to extend the ability of an individual to modify features of the surrounding environment. Although many animals use simple tools, only human beings, whose use of stone tools dates back hundreds of millennia, have been observed using tools to make other tools. The set of tools required to perform different tasks that are part of the same activity is called gear or equipment.

Fig. 4.44: Multimeters Special Tool

Pneumatic Guns

This tool is run by the air compressor; Minimum 100 Psi is required to run this tool.

Fig. 4.45: Pneumatic Guns

Bench Grinder

A bench grinder is a benchtop type of grinding machine used to drive abrasive wheels. Depending on the bond and grade of the grinding wheel, it may be used for sharpening cutting tools such as tool bits, drill bits, chisels, and gouges. Alternatively, it may be used to roughly shape metal prior to welding or fitting.

Fig. 4.46: Bench Grinder

Hand Drill Machine: - The rotating edge of the drill exerts a large force on the work piece and the hole is generated. The removal of metal in a drilling operation is by shearing and extrusion. ... The machine is capable of drilling holes in the work pieces in any position.

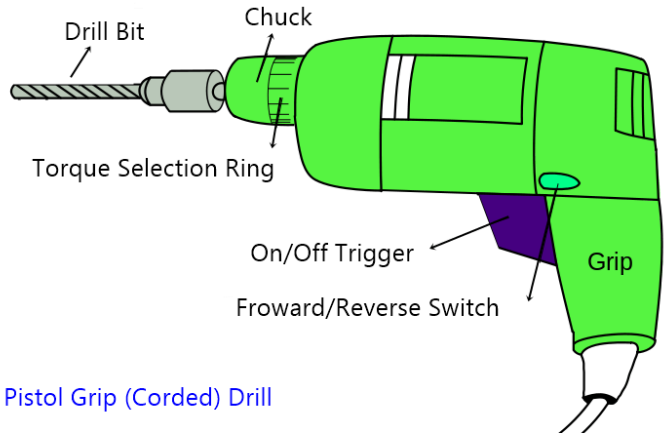


Fig. 4.47: Hand Drill Machine

Air Hoses Blower: - The blower draws air on the intake side, a partial vacuum (reduction in atmospheric pressure) occurs within

the vacuum hose. High pressure flows to low pressure, so air begins to flow through the hose. The greater the pressure differential, the faster the air will move through the hose.

Fig. 4.48: Air Hoses Blower

Check Your Progress

A) Fill in the Blanks:

1. _____ is a special tool used for measuring electrical properties such as voltage, current, and resistance.
2. _____ run on compressed air from an air compressor, requiring a minimum of 100 Psi to function.
3. A bench grinder is used for driving abrasive _____ and can be utilised for sharpening cutting tools or roughly shaping metal.
4. The blower creates a partial vacuum within the vacuum hose, drawing air from the intake side due to _____.

B) Multiple Choice Questions:

1 What is the purpose of a multimeter?

a) To shape metal prior to welding

b) To measure voltage, current, and resistance in electrical systems

c) To fasten and nail objects together

d) To draw air through hoses

2. How do pneumatic guns operate?

a) They utilise compressed air from an air compressor

b) They generate rotational force to create holes
c) They measure pressure differentials
d) They shape metal prior to welding

3. What is the primary function of a bench grinder?
a) To sharpen cutting tools like drill bits and chisels
b) To measure electrical properties
c) To draw air through hoses
d) To shape metal prior to welding

4. How does a hand drill machine create holes?
a) By measuring voltage, current and resistance
b) By utilising compressed air
c) By exerting rotational force on the workpiece
d) By drawing air through hoses

C. Answer the Following Question

1. What are the maintenance tasks involved in servicing a motorcycle ramp, and how do they contribute to its optimal performance and durability?
2. How does a battery charger utilise electromagnetic energy through inductive coupling to charge batteries, and what advantages does this method offer over traditional metal contact chargers?
3. What is the significance of tools in human evolution, and how do they enhance our ability to modify the environment? Provide examples of tools and their specific applications.
4. How does an air hoses blower utilise pressure differentials to generate airflow, and what factors affect the speed of air movement through the hose?

Activity

1. Identify the Service Equipment in the Electric Vehicle Workshop.
2. Sketch Electric Vehicle workshop.
3. Project Field Trip-Visit a service station and make an inventory of equipment used. Also find out the challenges in using this service equipment.

Session 6: EVs Diagnostic Tools

EV diagnostic, or Electric Vehicle diagnostic, is like a check-up for electric cars. It's all about using special tools and methods to find and

fix problems in an electric vehicle. Just like when you go to the doctor for a check-up, electric cars need a thorough examination to make sure they're working correctly and to fix any issues that might come up.

Here are the main things we look at during EV diagnostic:

1) Computer System: Just like our brain controls our body, the computer system in an electric car controls important parts like the battery and the motor. It can also save codes that help us find problems. Special tools can connect to the computer to read these codes and find any issues.
2) Battery: The battery in an electric car is super important. It affects how well the car runs and how far it can go. We use special tools to check the battery's health, like its charge, voltage, and temperature. If there's something wrong, we can find it.
3) Charging System: Electric cars need to charge to work, and the charging system makes it happen. We use tools to make sure the charging system is doing its job properly.
4) Other Components: Electric cars have many other parts that affect how they work and how safe they are, like brakes, suspension, and steering. Sometimes, we need to check these too.

To do all this, we use special tools that are made just for electric cars. Some of these tools are:

1. **OBD Scanners:** OBD stands for On-Board Diagnostics and is a computer system inside of a vehicle that tracks and regulates a car's performance. This on-board computer system collects information from the network of sensors inside the vehicle, which the system can then use to regulate car systems or alert the user to problems. A technician can then simply plug into the OBD system to collect vehicle data and diagnose the problem. OBD systems have been a great help in helping users better understand vehicle diagnostics.

Fig.4.49: OBD Scanner

2. **Battery tester:** The battery tester is specially designed to test the health of electric vehicle batteries. These tools measure the battery's state of charge, voltage and temperature and can identify any failure or damage. Testing electric vehicle (EV) batteries is crucial for ensuring their quality and safety. ITC owns a device called the Life Cycle Tester, which is a piece of lab equipment used to check the lifespan of batteries. This tester is specifically designed for automotive batteries and can perform various tests on them. Here are some of the tests it can carry out:

- Checking the information and durability marked on the battery.
- Identifying the materials used in the battery.
- Measuring the battery's discharge capacity.
- Evaluating how well the battery holds a charge during storage.
- Assessing its performance under constant discharge with daily use.
- Observing how the battery behaves during recharging.
- Determining its lifespan when operating at a high temperature of 40 degrees Celsius.
- Studying the effects of extreme temperatures, either 55 or 60 degrees Celsius.
- Testing how the battery handles over-discharge.
- Examining its sensitivity to thermal runaway.
- Evaluating how well it performs in cold temperatures.
- Checking the battery's stability when subjected to elevated internal pressure and temperature.

- Assessing its resistance to mechanical abuse during installation.

Fig. 4.50: Battery tester

Battery testing is crucial to understand the condition, life cycle, real capacity, and state of charge of a battery or battery bank. There are two main methods for testing batteries: invasive and non-invasive methods. These methods provide information about the battery but may not explain the underlying reasons. Here are some common methods for battery testing:

Invasive Methods:

i. Electrolyte density determination: Estimates the State of Health (not applicable for VRLAB batteries).
ii. Electrode potential measurements: Determine the degradation of the positive and negative active masses in the battery.

Non-Invasive Methods:

i. Open circuit and float voltage: Estimate the State of Health and State of Charge.
ii. Battery/cell temperature monitoring: Detect State of Health and shorts.
iii. Charge/discharge voltage measurement: Determine State of Health and State of Charge.
iv. DC current discharge: Calculate the actual battery capacity.
v. Discharge Testing: Discharge testing is a primary method in battery testing. It provides precise results and reveals the real capacity of a battery or a battery string (a group of two or more batteries or cells connected in series to achieve the desired voltage). However, it may not

always indicate the state of health of the battery string. Discharge testing can be done in different ways, such as full discharge, partial discharge, or limited discharge. The Life Cycle Tester at the Institute of Testing and Certification India Pvt Ltd is designed to test batteries according to industry standards, particularly automotive batteries. It performs discharge capacity tests using a constant current system with forced air-cooled power transistors. This system offers maximum flexibility for charging and discharging and is built to withstand short-circuits and fluctuations in input power.

3. **Oscilloscope:** An oscilloscope for electric vehicles is a specialized testing and diagnostic tool used to analyse and monitor the electrical systems within an electric vehicle (EV). This device helps technicians and engineers troubleshoot, measure, and visualize various electrical signals and waveforms in the EV's components and systems. It is used to identify and diagnose electrical issues within the EV's systems, including the battery, motor controller, charging systems, and various sensors

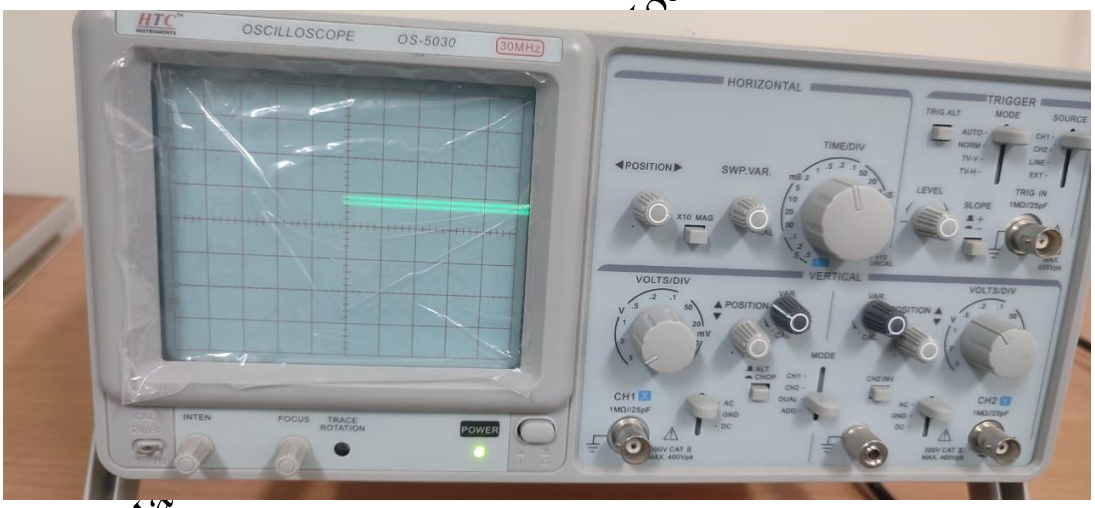


Fig. 4.51: An Oscilloscope

Using an oscilloscope can be a bit intimidating for beginners, but it becomes more manageable when you follow a step-by-step procedure. Here's a simplified guide on how to use an oscilloscope:

Step 1: Power on and Connect

Power On: Start by turning on the oscilloscope using the power button or switch.
Probe Connection: Connect the probe to one of the input channels on the oscilloscope. Ensure that the probe is properly seated and secure.

Ground Clip: Attach the ground clip of the probe to a suitable ground point. This could be the reference ground or a known ground in your circuit.

Step 2: Adjust Vertical Settings

Select Channel: If your oscilloscope has multiple input channels, select the channel you want to use. Usually, it's labelled as "CH1" or "CH2."
Voltage Range: Set the voltage range or sensitivity for the channel. This determines the vertical scale of the displayed waveform. Adjust it according to the expected signal amplitude.
Position: Adjust the vertical position control to center the waveform vertically on the screen.

Step 3: Adjust Horizontal Settings

Time base: Set the time base or horizontal scale. This controls the time per division on the screen. Choose an appropriate time scale for the signal you're measuring.
Trigger Level: Adjust the trigger level control to stabilize the waveform on the screen. This helps to trigger the scope at a specific point on the waveform.

Step 4: Trigger Settings

Trigger Source: Select the trigger source. This is the channel that the oscilloscope will use to trigger the display. You can choose the same channel you're probing or a different one.
Trigger Type: Set the trigger type, which could be rising edge, falling edge, or others, depending on your signal.

Step 5: Acquire Data

Run/Stop: Set the oscilloscope to "Run" mode if you want it to continuously display the waveform. Use "Stop" mode to freeze the display for further analysis.

Step 6: Probe Your Circuit

Probe Placement: Carefully probe your circuit at the point of interest. Ensure that the probe tip makes a secure connection.

Step 7: Interpret the Waveform

Interpretation: Examine the waveform on the screen. You can measure voltage levels, time intervals, and other parameters based on the scale settings.

Step 8: Adjust and Fine-Tune

Fine-Tuning: If necessary, adjust the vertical and horizontal settings to get a clearer view of the waveform.

Step 9: Save or Capture Data

Save Data: Some oscilloscopes allow you to save captured waveforms or screen images for documentation or further analysis.

Step 10: Power Off

Power Off: When you're done, turn off the oscilloscope to conserve power and extend its lifespan.

4. **Current Clamp:** This tool helps us measure electricity flow in the car's circuits. Using a current clamp in an EV allows you to measure current without disrupting the electrical circuit, making it a valuable tool for troubleshooting, maintenance, and analysis of electric vehicle systems. Always follow safety precautions and guidelines provided by the current clamp's manufacturer and the EV manufacturer to ensure safe and accurate measurements.

Fig. 4.52: Current Clamp

Here's a step-by-step procedure for using a current clamp in an EV:

Step 1: Safety Precautions

- Safety Gear: Wear appropriate safety gear, such as gloves and safety glasses, when working with electrical components in an EV.
- Power Off: Ensure that the EV is powered off and disconnected from any charging source to prevent electrical shock or damage to the clamp.

Step 2: Identify the Measurement Point

- Locate the Current Carrying Conductor: Identify the specific wire or conductor from which you want to measure the current. This could be a battery cable, a motor connection, or another part of the electrical system.

Step 3: Prepare the Current Clamp

- Set the Clamp: Set the current clamp to the appropriate range for the expected current level you want to measure. Check the clamp's user manual for guidance.
- Calibrate if Necessary: Some clamps may require periodic calibration. Consult the user manual for instructions on calibration if needed.
- Zero the Clamp: Before attaching the clamp to the conductor, it's a good practice to zero the clamp, especially if it has the zeroing capability. This helps to eliminate any offset or residual current.

Step 4: Attach the Current Clamp

- Open the Clamp: Open the jaws of the current clamp.
- Position the Clamp: Position the opened jaws around the current-carrying conductor. Ensure that the jaws are securely and completely closed around the conductor.

Step 5: Measure Current

- Read the Display: Read the current measurement displayed on the current clamp's screen. Ensure the measurement is stable and accurate.
- Record the Data: If necessary, record the current measurement for future reference or analysis.

Step 6: Disconnect the Clamp

- Release the Clamp: Carefully release the clamp from the conductor.

Step 7: Power ON and Connect

- Power Off: Turn off the current clamp to conserve battery life.

Step 8: Safety and Maintenance

- Safety: Store the current clamp in a safe location, away from moisture, extreme temperatures, and physical damage.
- Calibration and Maintenance: Periodically check and calibrate the current clamp according to the manufacturer's recommendations to ensure accurate measurements.
- User Manual: Refer to the user manual for your specific current clamp for any maintenance and care instructions.

5. **Tire Pressure Monitoring Systems (TPMS):**

TPMS helps keep you safe by warning when your tires are under-inflated, which can be dangerous for driving. The TPMS warning light is a yellow symbol on the dashboard that looks like a tire with an exclamation point inside. There are two types: indirect and direct TPMS.

Indirect TPMS: Uses wheel speed sensors to check how fast the tires are rotating. Compares the tire rotation with other vehicle data to determine if a tire is underinflated.

Direct TPMS: Uses pressure sensors inside each tire to monitor tire pressure and temperature. Sends this data to a control module and then to the dashboard indicator.

Both types of TPMS serve the same purpose: to keep you safe by warning about low tire pressure. TPMS is not a replacement for manual tire pressure checks but is a useful tool for car maintenance.

Fig. 4.53: Tire Pressure Monitoring Systems (TPMS)

Check Your Progress

A. Fill in the Blanks

1. OBD stands for _____.
2. On-Board Diagnostics system collects information from the network of _____ inside the vehicle.
3. _____ is crucial to understand the condition, life cycle, real capacity, and state of charge of a battery or battery bank.
4. An oscilloscope for electric vehicles is a specialized testing and diagnostic tool used to _____ and _____ the electrical systems within an electric vehicle (EV).
5. _____ helps keep you safe by warning when your tires are under-inflated, which can be dangerous for driving.

B. Multiple Choice Questions:

1. What does OBD stand for in the context of EV diagnostics?
a) On-Battery Diagnostics
b) On-Board Diagnostics
c) Off-Board Diagnostics
d) Optimal Battery Diagnostic

2. Why is battery testing important in EV diagnostics?
a) To measure tire pressure
b) To check the state of the computer system
c) To assess the battery's health and safety
d) To monitor the vehicle's charging system

3. What is the main purpose of using an oscilloscope in EV diagnostics?
a) To charge the battery
b) To test the brakes
c) To analyse and monitor electrical systems
d) To measure tire pressure

5. What are the two types of TPMS mentioned?
a) Direct and Indirect
b) Battery and Brake
c) OBD and Current Clamp
d) Oscilloscope and Computer System

C. Answer the following questions:

1. Why is it important to perform EV diagnostic tests regularly?
2. What is the purpose of using OBD scanners in electric vehicle diagnostics?
3. How can an oscilloscope be used in electric vehicle diagnostics, and what are the steps to use it effectively?
4. Explain the purpose of a current clamp in electric vehicle diagnostics, and provide a step-by-step procedure for using it in an EV.

Activity

1. Conduct a simple battery testing experiment in the classroom with a basic battery and a tester to measure its voltage and state of charge.
2. Visit an Electric Vehicle Workshop and perform the practical using a current clamp in an EV in the presence of Experts.

Module 5	Routine Service and Repair of an EV

Module Overview

Maintenance is an essential part of ensuring that machines, equipment and systems remain in optimal condition and perform efficiently. Maintenance involves regular inspections, repairs, and replacements to prevent malfunctions, reduce downtime, and extend the lifespan of the equipment.

One critical aspect of maintenance is the maintenance schedule. A maintenance schedule is a plan that outlines the tasks and activities required to maintain and service a particular machine or system at specific intervals. It serves as a guide for the maintenance team and helps ensure that all necessary maintenance tasks are performed on time. Maintenance in Electric Vehicles (EVs) is critical to ensure that the vehicle operates at its optimal level and remains safe to drive. EVs have several unique components that require regular maintenance to ensure their proper functioning.

Learning Outcome

After completing this module, you will be able to:

- Understand and explain the importance of a regular maintenance schedule for electric vehicles.
- Identify the key components and systems that require routine maintenance and their recommended service intervals.
- Understand the purpose and importance of a job card in vehicle service and maintenance.
- Create and accurately complete a job card, including customer details, vehicle information, and service tasks.
- Understand and explain the steps involved in the SOP for receiving vehicles for service.
- Follow the SOP accurately to ensure a consistent and professional approach to vehicle intake.
- Understand the process of creating and issuing invoices for vehicle service and repairs.
- Demonstrate the ability to prepare detailed and accurate invoices.
- Identify and describe the key components of electric vehicles that require regular inspection and testing.
- Understand and apply the procedures for inspecting and testing these components to ensure they are functioning correctly.

- Understand the risks associated with high-voltage systems in electric vehicles.
- Identify and describe the safety precautions and protocols for working with high-voltage systems.
- Demonstrate the ability to safely handle, maintain, and repair high-voltage components in electric vehicles.

Module Structure

Session 1: Maintenance Schedule
Session 2: Job Card
Session 3: Standard Operating Procedure (SOP) for Receiving Vehicles
Session 4: Invoicing Vehicle Delivery and Handling Complaints
Session 5: Inspection and Testing of Electric Vehicle's Components
Session 6: Safety of The High-Voltage System

Session 1: Maintenance Schedule

Fig. 5.1: Routine service and repair of EV

Electric Vehicles (EVs) have gained significant popularity due to their environmental benefits and cost savings on fuel. As with any complex machinery, EVs require regular maintenance to ensure their optimal performance and longevity. In this session, we will explore the different types of maintenance specific to Electric Vehicles. By understanding these maintenance strategies, EV owners and operators can maximise the efficiency and reliability of their vehicles.

Scheduled maintenance and unscheduled maintenance in vehicles are two distinct approaches to keeping a vehicle in good working condition. Here's an explanation of each type:

1) Scheduled Maintenance:

Scheduled maintenance, also known as routine or preventive maintenance, is a planned and regular maintenance program for a vehicle. It involves performing specific tasks and inspections at predetermined intervals based on the manufacturer's recommendations, service schedule, or the vehicle's usage. The primary goal of scheduled maintenance is to prevent potential issues, extend the vehicle's lifespan, and ensure its safe and efficient operation. Some common examples of scheduled maintenance tasks include:

a) Oil changes: Regularly changing the oil filter.
b) Tire rotations: Ensuring even tire wear and longer tire life.

Tire Rotation and Alignment

Maintaining proper tire rotation and alignment helps in extending tire life, improving vehicle handling, and maximising energy efficiency. Regular checks and adjustments of tire pressure are also essential for optimal driving performance.

Fig. 5.2: Inspection of tyre Inflation

c) Brake inspections: Checking brake pads, rotors, and brake fluid.

Brake System Inspection

Inspection of the braking system is necessary to ensure its reliability and effectiveness. This includes checking brake pads, rotors, and hydraulic systems, and addressing any signs of wear or malfunction.

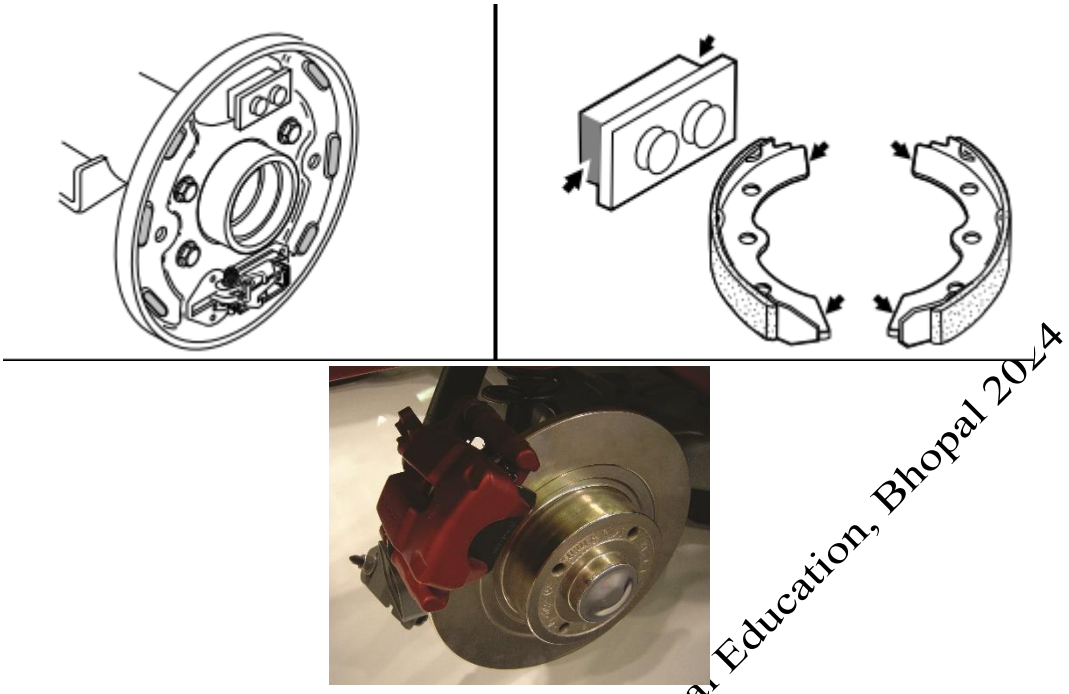


Fig. 5.3: Brake System Inspection

d) Fluid checks: Examining and topping up fluids like coolant, transmission fluid, and power steering fluid.

e) Charging System Check

Regular inspection of the charging system, including charging cables, connectors, and on-board charging units, helps maintain efficient charging performance and ensures safe and reliable charging experiences.

Fig. 5.5: Charging System Check

f) High Voltage System Inspection

EVs operate with high-voltage systems, and scheduled maintenance involves checking the integrity of high-voltage cables, connectors, and safety systems to prevent any potential risks.

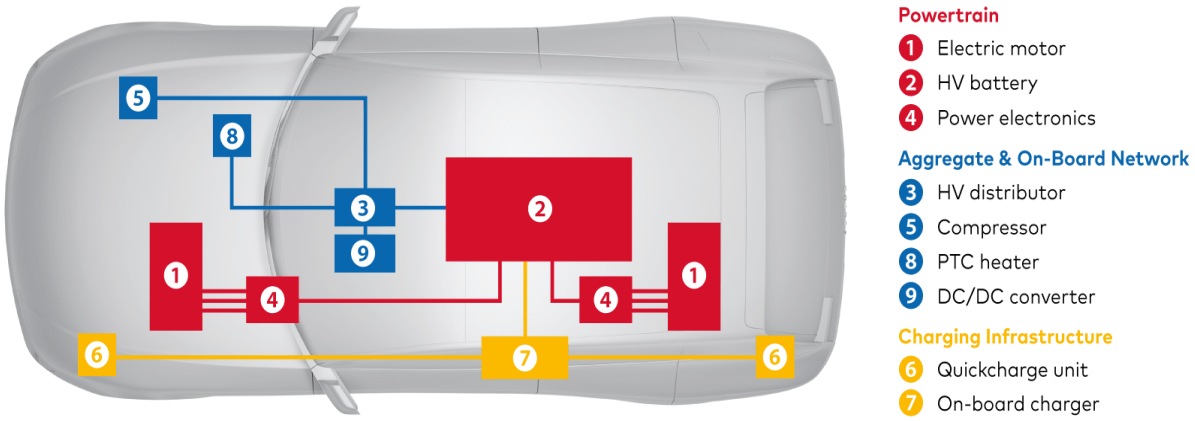


Fig. 5.6: High Voltage System

g) Electric Motor Inspection

The electric motor is a critical component in an EV, and scheduled maintenance involves inspecting its condition, ensuring proper lubrication, and addressing any noise or vibration issues.

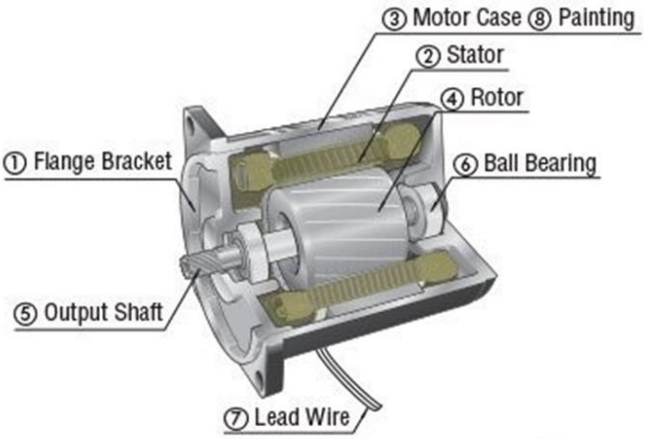


Fig. 5.4: Electric Motor Inspection

h) Battery Health Check

Regular assessment of the battery pack's health and capacity is crucial for optimising the vehicle's range and performance. This involves checking for any abnormalities, balancing individual cell voltages, and ensuring proper cooling and ventilation of the battery system.

i) HVAC System Maintenance

The heating, ventilation, and air conditioning (HVAC) system in an Electric Vehicle plays a vital role in maintaining cabin comfort. Periodic maintenance involves cleaning or replacing air filters, checking refrigerant levels, and inspecting HVAC components for optimal performance.

Scheduled maintenance helps prevent breakdowns, reduces the risk of costly repairs, and ensures the vehicle's performance and safety. These tasks are typically planned and documented, making it easier to keep track of when they are due.

2) Unscheduled Maintenance:

Unscheduled maintenance, also referred to as reactive or breakdown maintenance, is the repair and servicing of a vehicle in response to unexpected failures, malfunctions, or issues. It is not planned and can occur at any time during the vehicle's operation. Unscheduled maintenance is typically necessary when something goes wrong with the vehicle's components, systems, or equipment. Common examples of unscheduled maintenance include:

a) Battery Degradation: Electric vehicle batteries are subject to gradual degradation over time, which can result in reduced range and performance. This degradation is influenced by factors such as temperature, charging patterns, and vehicle usage. When battery capacity drops significantly, it may necessitate either a battery replacement or refurbishment. Regular maintenance includes monitoring the battery's state of health (SOH) and state of charge (SOC) to identify potential issues early.

b) Tire Wear: EVs tend to be heavier than traditional vehicles due to their battery packs, and this added weight can lead to increased tire wear. Uneven tire wear can result in reduced efficiency and handling.

Regular tire rotation and alignment checks are important to maintain optimal tire performance.

c) Regenerative Braking System: Many electric vehicles use regenerative braking to recover energy and extend the vehicle's range. Over time, the regenerative braking system components, such as brake pads and rotors, may wear out and require replacement. Proper maintenance of the braking system is essential for safe and efficient operation.

d) Electric Motor and Inverter: The electric motor and inverter are critical components of an electric vehicle's propulsion system. Issues with these components, such as overheating, electrical faults, or mechanical wear, can lead to reduced power output and efficiency. Regular checks and maintenance are required to keep these components in good working condition.

e) Charging System: Charging infrastructure for EVs can vary, and issues with charging connectors, cables, or chargers may occur. Loose connections, cable damage, or charger malfunctions can disrupt the charging process. Regular inspection and maintenance of the charging system can help prevent these issues.

f) Electrical Systems: Electric vehicles have complex electrical systems that control various functions, including climate control, entertainment, and safety features. Problems such as sensor malfunctions, software glitches, or electrical faults can lead to issues with these systems. Regular software updates and diagnostic checks are necessary to ensure proper functionality.

g) Cooling System: EVs often have dedicated cooling systems to maintain the optimal temperature of the battery and other critical components. Issues with the cooling system, such as coolant leaks or pump failures, can lead to overheating and damage to the components. Regular inspections and maintenance of the cooling system are crucial for preventing such problems.

h) Suspension and Steering: The added weight of the battery pack in EVs can affect the suspension and steering components over time. Worn-out shocks, struts, or steering components can lead to reduced ride comfort and handling. Regular inspections and replacement of these components are essential for vehicle safety and performance.

Unscheduled maintenance can be costlier and inconvenient than scheduled maintenance because it often requires immediate attention and can lead to unexpected downtime. It is essential to respond to unscheduled maintenance promptly to prevent further damage and ensure safety.

Electric Vehicles (EVs) require regular maintenance to keep them running smoothly and efficiently. While EVs have fewer moving parts than traditional gasoline-powered cars, they still require attention and care to maintain their battery, motor, and other critical components.

Here are some key areas to focus on when maintaining an EV:

i. Battery health: The battery is the most critical component of an EV, and its health directly impacts the car's range and performance. Regularly check the battery's state of charge, and follow the manufacturer's guidelines for charging and maintenance.
ii. Motor and drivetrain: While EV motors have fewer moving parts than gas engines, they still require maintenance to ensure optimal performance. Keep the motor and drivetrain clean and free of debris, and have them inspected by a professional mechanic regularly.
iii. Brakes: EVs rely on regenerative braking, which uses the motor to slow the car down and recharge the battery. However, traditional brakes still play a critical role in stopping the car. Make sure the brake pads are in good condition, and have them checked and replaced as needed.
iv. Tires: Tires can impact an EV's range and efficiency. Keep them properly inflated and rotated, and replace them when they show signs of wear.
v. Software updates: EVs rely heavily on software to manage the battery, motor, and other systems. Regularly check for and install updates to ensure the car is running the latest and most efficient software.

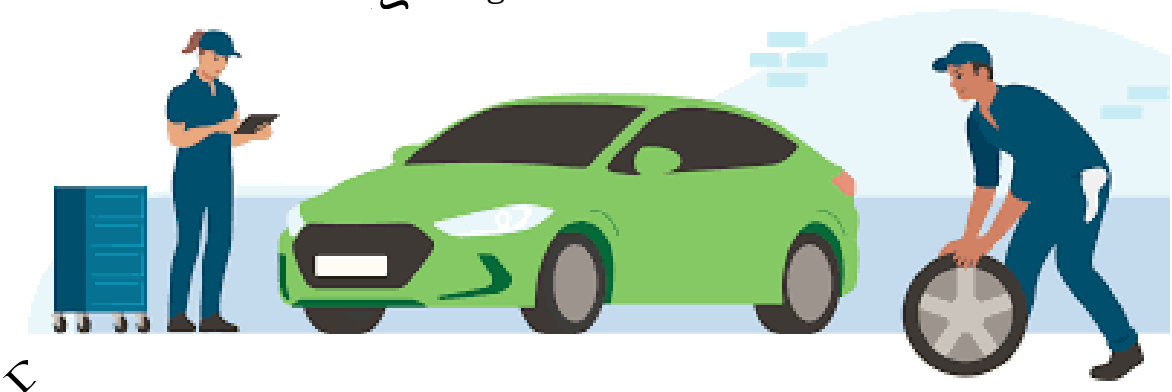


Fig. 5.7: Maintenance of vehicle

By following these maintenance tips and regularly servicing your EV, you can keep it running smoothly and efficiently for years to come.

Check Your Progress

A) Fill in the Blanks:

1. Tire rotation and alignment help extend _____**,** improves vehicle handling, and maximise energy efficiency in Electric Vehicles.
2. Brake system inspection for EVs involves checking brake pads, rotors, hydraulic systems, and addressing any signs of _____**.**
3. _____ also known as corrective maintenance, focuses on addressing failures or malfunctions promptly in Electric Vehicles.

B) Multiple Choice Questions:

1. The Periodic maintenance in Electric Vehicles involve _____.
a) Maintenance performed after a breakdown occurs.
b) Maintenance tasks performed at regular intervals to prevent failures.
c) Maintenance performed according to a predetermined schedule.
d) Maintenance focused on diagnosing and repairing faults.

2. _____ is crucial to assess during periodic maintenance for optimising an Electric Vehicle's range and performance?
a) Tire rotation and alignment
b) Brake system
c) HVAC system
d) Battery pack

3. The purpose of scheduled maintenance in Electric Vehicles
a) To address unexpected failures promptly
b) To perform repairs after a breakdown occurs
c) To ensure reliable charging experiences
d) To keep the vehicle in excellent condition and prevent unexpected failures

4. Which area of an Electric Vehicle requires regular attention and maintenance to maintain optimal performance?
a) Battery health
b) Fuel system
c) Exhaust system
d) Spark plugs

C) Answer the Following Questions:

1. What is the purpose of scheduled maintenance in Electric Vehicles?
2. What are some examples of scheduled maintenance tasks for Electric Vehicles?
3. What is Unscheduled maintenance, and what are the steps involved in addressing breakdowns in Electric Vehicles?

Activity
1. Fill the check list of routine maintenance schedule. Draw the flow chart of the service layout for Electric Vehicle Maintenance.

Session 2: Job Card and Warranty Card

A job card is a document used to track and record the work performed on a vehicle or piece of equipment. It is typically used by service centres, garages, and other facilities that provide maintenance or repair services.

The job card contains information about the vehicle or equipment, including the make and model, year, and any other important details. It also includes the name of the customer or owner of the vehicle, as well as their contact information.

The job card is used to track the work performed on the vehicle or equipment, including the date the work was performed on the type of work done, and any parts or materials used. It may also include the name of the technician, who performed the work and their signature.

The job card serves as a record of the work performed, which can be useful for future reference or warranty claims. It can also be used to track the time and materials used for each job, which can help with billing and inventory management.

In some cases, the job card may also include an estimate of the cost of the work to be performed, as well as any approvals or authorisations required from the customer or owner.

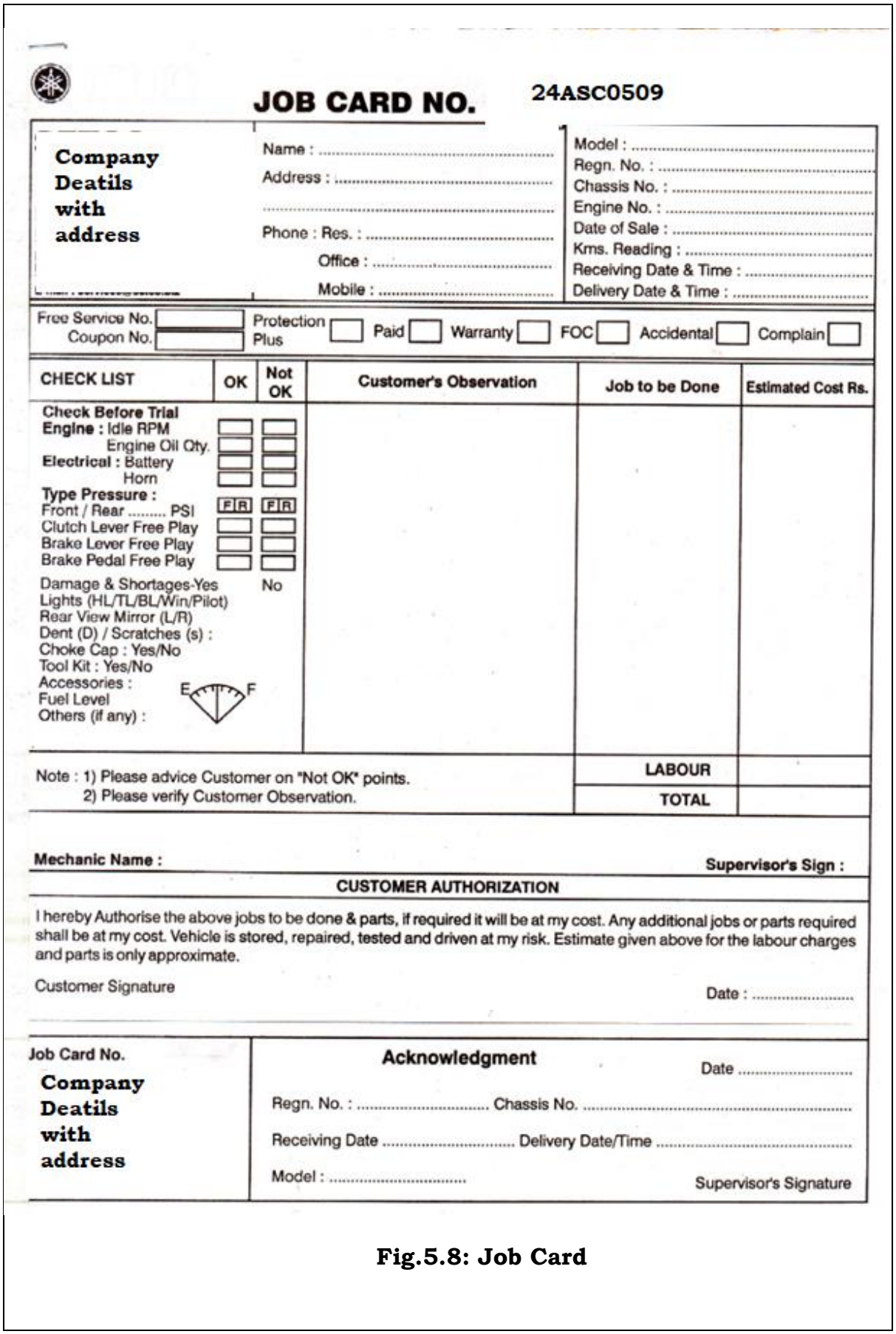
Common activities in the workshop:

- Job card and its filling procedure
- Washing of vehicle and Washing Procedure
- Engine Minor tune up
- Oil Replacement
- Checking of battery electrolyte level and top-up
- Clutch and brake free play and their adjustment
- Lighting System, its various parts and their checking
- Identification of greasing points of wheelers and procedure of greasing.
- Checking of tyre inflation and procedure of inflation.

Job card and its filling procedure

When a vehicle owner enters in service centre, he/she is attended by supervising engineer. Customer informs about vehicle defect. After getting the feedback from the vehicle owner/driver regarding defects of the vehicle, the supervising engineer in a service station or workshop carry out an inspection on it. The defects pointed out or listed are noted down in a standard format, which is called the Job Card or Work Order.

In order to indicate his satisfaction with the diagnosis made by the supervising engineer, the customer of the vehicle puts his/her signature on the Job card before the repairs on the vehicle are started. The work is then assigned to the appropriate person to carry out the repairs, and the supervisor puts his/her signature on the job card. The work order/Job card is prepared in duplicate.



JOB CARD NO. 24ASC0509

Company Deatils with address

Name : .....
Address : .....
.....
Phone : Res. : .....
Office : .....
Mobile : .....

Model : .....
Regn. No. : .....
Chassis No. : .....
Engine No. : .....
Date of Sale : .....
Kms. Reading : .....
Receiving Date & Time : .....
Delivery Date & Time : .....

Free Service No. / Coupon No. | Protection Plus ☐ | Paid ☐ | Warranty ☐ | FOC ☐ | Accidental ☐ | Complain ☐

CHECK LIST	OK	Not OK	Customer's Observation	Job to be Done	Estimated Cost Rs.
Check Before Trial					
Engine : Idle RPM	☐	☐			
Engine Oil Qty.	☐	☐			
Electrical : Battery	☐	☐			
Horn	☐	☐			
Type Pressure :					
Front / Rear ..... PSI	F R	F R			
Clutch Lever Free Play	☐	☐			
Brake Lever Free Play	☐	☐			
Brake Pedal Free Play	☐	☐			
Damage & Shortages-Yes		No			
Lights (HL/TL/BL/Win/Pilot)					
Rear View Mirror (L/R)					
Dent (D) / Scratches (s) :					
Choke Cap : Yes/No					
Tool Kit : Yes/No					
Accessories :					
Fuel Level (E F)					
Others (if any) :					

Note : 1) Please advice Customer on "Not OK" points.
2) Please verify Customer Observation.

LABOUR	
TOTAL	

Mechanic Name : **Supervisor's Sign :**

CUSTOMER AUTHORIZATION

I hereby Authorise the above jobs to be done & parts, if required it will be at my cost. Any additional jobs or parts required shall be at my cost. Vehicle is stored, repaired, tested and driven at my risk. Estimate given above for the labour charges and parts is only approximate.

Customer Signature Date : .....

Job Card No.

Company Deatils with address

Acknowledgment Date .....

Regn. No. : ..... Chassis No. .....

Receiving Date ..... Delivery Date/Time .....

Model : ..... Supervisor's Signature

Fig.5.8: Job Card

Contents of a standard Job Card:

- Job card Number.
- Name address and phone of the Service Centre.
- Name address and phone of customer.
- Details of vehicle such as – Make; Model, Registration, Chassis No, Engine, Date of Sale, Kms. Reading, Receiving date and time and delivery date and time by the service centre.
- Check list before trial
- Customer's observation.
- Job to be done.
- Estimated cost in Rupees. for customer and Insurance company.
- Labour required
- Name of Mechanic.
- Name and Signature of Supervisor.
- Customer's authorisation for repair and his/her signature
- Acknowledgment.

Filling the Job Card:

Almost all the information's must be properly filled in the job card by the supervisor and has to be signed by him/her and the customer also has to sign on the authorization for work column. Then the repairing or servicing job on the vehicle is taken over. A standard job card is shown below. The student must practice to fill the same.

WARRANTY CARD

A warranty card in an Electric Vehicle (EV) is a document provided by the manufacturer or dealer that outlines the terms and conditions of the warranty coverage for the EV. It serves as proof of the warranty and provides important information regarding the warranty period, coverage, and any specific terms or limitations.

The warranty card typically includes the following details:

i. Warranty Period: It specifies the duration of the warranty coverage, which is usually expressed in terms of months or miles driven, whichever comes first.

ii. Covered Components: The warranty card lists the specific components or systems of the EV that are covered under the warranty. This can include the battery pack, electric motor, drivetrain, charging system, and other critical components.

iii. Warranty Coverage: It explains what types of repairs or replacements are covered under the warranty. This can include defects in materials or workmanship, mechanical failures, and certain types of malfunctions.

iv. Exclusions and Limitations: The warranty card may mention certain exclusions or limitations to the warranty coverage. For example, it may specify that regular maintenance or wear and tear items are not covered. It may also outline any conditions or requirements that need to be met to maintain the warranty, such as following recommended maintenance schedules or using authorised repair facilities.

v. Transferability: Some warranty cards indicate whether the warranty is transferable to subsequent owners if the EV is sold. This information is important for potential buyers to understand the remaining warranty coverage when purchasing a used EV.

vi. Claims Process: The warranty card provides instructions on how to make a warranty claim in case of a covered issue. It may outline the steps to take, such as contacting the manufacturer or authorised service centre, providing necessary documentation, and following any specific procedures.

CHECK YOUR PROGRESS

A) Fill in the Blanks:

1. A _____ is a document used to track and record the work performed on a vehicle or piece of equipment.
2. A job card may include an estimate of the work's cost, as well as approvals or authorisations from the _____.
3. A _____ in an EV is a document provided by the manufacturer or dealer that outlines the terms and conditions of the warranty coverage for the vehicle.
4. The warranty period specifies the duration of the warranty_____, usually expressed in months or miles driven.

B) Multiple Choice Questions:

1. What is the purpose of the job card in a service centre or workshop?
a) To track and record the work performed on a vehicle or equipment
b) To advertise the services provided by the workshop
c) To collect customer feedback on the quality of service
d) To document the payment details for the repairs

2. Which of the following information is typically included in a job card?
a) Make and model of the vehicle
b) Name and contact information of the customer

c) Date and type of work performed
d) All of the above

3. Why is the customer's signature important on the job card?
a) To indicate satisfaction with the diagnosis made by the supervising engineer
b) To authorise the repairs on the vehicle
c) To verify the accuracy of the recorded information
d) All of the above

4. What is the purpose of including the technician's signature on the job card?
a) To indicate the completion of the repairs
b) To confirm the technician's attendance at the workshop
c) To track the technician's performance and accountability
d) To collect feedback on the quality of the repairs

C) Answer the following Questions:

1) What is a job card and what is its purpose in a service centre or workshop?
2) What is the procedure for filling out a job card in a service centre or workshop?
3) Can you explain the importance of accurately filling in the job card for proper documentation and service record keeping?

Activity

1. Visit a nearby service centre to read and interpret workplace-related documents.
2. Evaluate job cards and interact with service advisors and superiors to identify customer needs.

Session 3: Standard Operating Procedure (Sop) For Receiving Vehicles

"Efficient and accurate vehicle reception is vital for organizations in transportation, logistics, and automotive industries. Developing and implementing a tailored Standard Operating Procedure (SOP) for vehicle reception can greatly improve operations, reduce errors, and enhance overall efficiency. In this session, we will guide you through the process of creating and implementing an effective SOP for receiving vehicles.

Importance of a Standard Operating Procedure (SOP) for Receiving Vehicles:

Having a standardised SOP for receiving vehicles offers several benefits:

- Ensures consistent and standardised procedures across different receiving teams or locations.
- Minimises errors and reduces the risk of overlooking important steps during the receiving process.
- Enhances operational efficiency by streamlining workflows and reducing time wasted on unnecessary tasks.
- Facilitates proper documentation and record-keeping, improving traceability and accountability.

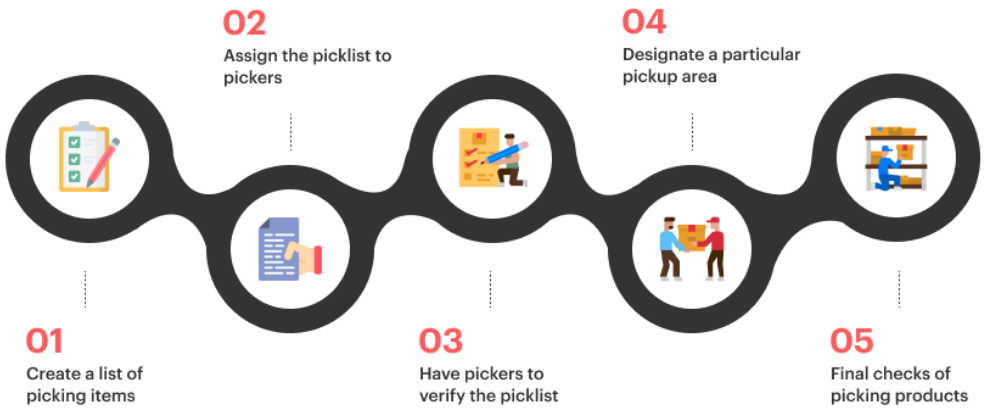


Fig.5.9: Flow Chart of SOP

SOP for Receiving Vehicles:

3.1. Preparing for Vehicle Arrival:

- Assign designated personnel responsible for receiving vehicles.
- Ensure the receiving area is clean, organised, and ready for vehicle inspections.
- Prepare necessary equipment's such as clipboards, measuring tools, flashlights, and cameras.
- Inform relevant stakeholders about the upcoming vehicle arrivals and expected delivery times.

3.2. Documentation and Inspection:

- Verify that all required documentation, such as delivery notes, manifests, and invoices, are in order.

- Inspect the exterior of the vehicle for any visible damage, scratches, or dents.
- Check the interior of the vehicle for cleanliness and ensure all accessories or extras are present as per the documentation.
- Validate the vehicle identification number (VIN) against the provided documents to ensure accuracy.
- Take photographs or videos of the vehicle from different angles to document its condition accurately.

3.3. Unloading and Checking the Vehicle:

- Use appropriate equipment such as forklifts or ramps, to safely unload the vehicle.
- Conduct a thorough inspection of the cargo area to ensure it matches the documentation.
- Check the condition and quantity of goods against the packing list or bill of lading.
- Inspect the vehicle for any signs of damage or tampering during transportation.
- Verify the functionality of vehicle components, such as lights, horn, wipers, and indicators.
- Check the tire pressure and overall condition of the tires.
- Test the vehicle's brakes and ensure they are functioning properly.
- Conduct a visual inspection of the engine bay for any leaks or abnormalities.
- Ensure that all required accessories, spare parts, and tools are present and in good condition.

3.4. Reporting and Record-Keeping:

- Document all findings, observations, and discrepancies in a standardised report.
- Include detailed information about the vehicle's condition, any damages, missing items, or other issues.
- Take note of the date, time, and personnel involved in the receiving process.
- Communicate any significant issues or discrepancies to the appropriate departments or stakeholders.
- Maintain accurate records of the received vehicles, including documentation, inspection reports, and photographs.
- Store the records in a secure and organised manner for future reference or auditing purposes.

Creating a clear set of rules (Standard Operating Procedure or SOP) for receiving vehicles is important. It helps things run smoothly, reduces mistakes, and makes things work better. This will guide you through the process step by step. It will help you make the vehicle receiving process more efficient, improve how you keep records, and make sure you don't miss anything important. By sticking to the SOP, you can make your organisation's vehicle-receiving operations work better overall and be more accurate.

Check Your Progress

Fill in the Blanks:

1. Implementing a _____ specifically tailored for receiving vehicles can significantly improve operations, minimise errors, and enhance overall efficiency.
2. Facilitates proper _____ and record-keeping, improving traceability and accountability.
3. Validate the _____. Against the provided documents to ensure accuracy.
4. Store the _____ in a secure and organised manner for future reference or auditing purposes.

Multiple Choice Questions:

1. What is the purpose of implementing a Standard Operating Procedure (SOP) for receiving vehicles?
a) To increase vehicle sales
b) To enhance operational efficiency and minimise errors
c) To promote brand awareness
d) To reduce customer complaints

2. What is one benefit of proper documentation and record-keeping in the receiving process?
a) Improved vehicle performance
b) Enhanced customer satisfaction
c) Better traceability and accountability
d) Reduced fuel consumption

3. Which of the following is a step involved in preparing for vehicle arrival according to the SOP?
a) Conducting a detailed vehicle inspection
b) Checking tire pressure and tread depth
c) Assigning designated personnel responsible for receiving vehicles
d) Reviewing the vehicle's maintenance history

4. What should be done during the inspection of the vehicle's exterior?
a) Checking the cleanliness of the interior
b) Verifying the accuracy of the vehicle identification number (VIN)
c) Testing the functionality of vehicle components
d) Ensuring all accessories are present as per the documentation

C. Short Answer Questions:

1. What are the benefits of implementing a Standard Operating Procedure (SOP) for receiving vehicles?
2. What are the key steps involved in preparing for vehicle arrival according to the SOP?
3. Why is it important to have a standardised SOP for receiving vehicles?
4. How can the SOP for receiving vehicles help in minimising errors and improving overall efficiency?

Activity

1. Demonstrate how to perform routine service repairing and maintenance activities on the various systems, the aggregate of an EV as per as SOP.

Session 4: Invoicing Vehicle Delivery and Handling Complaints

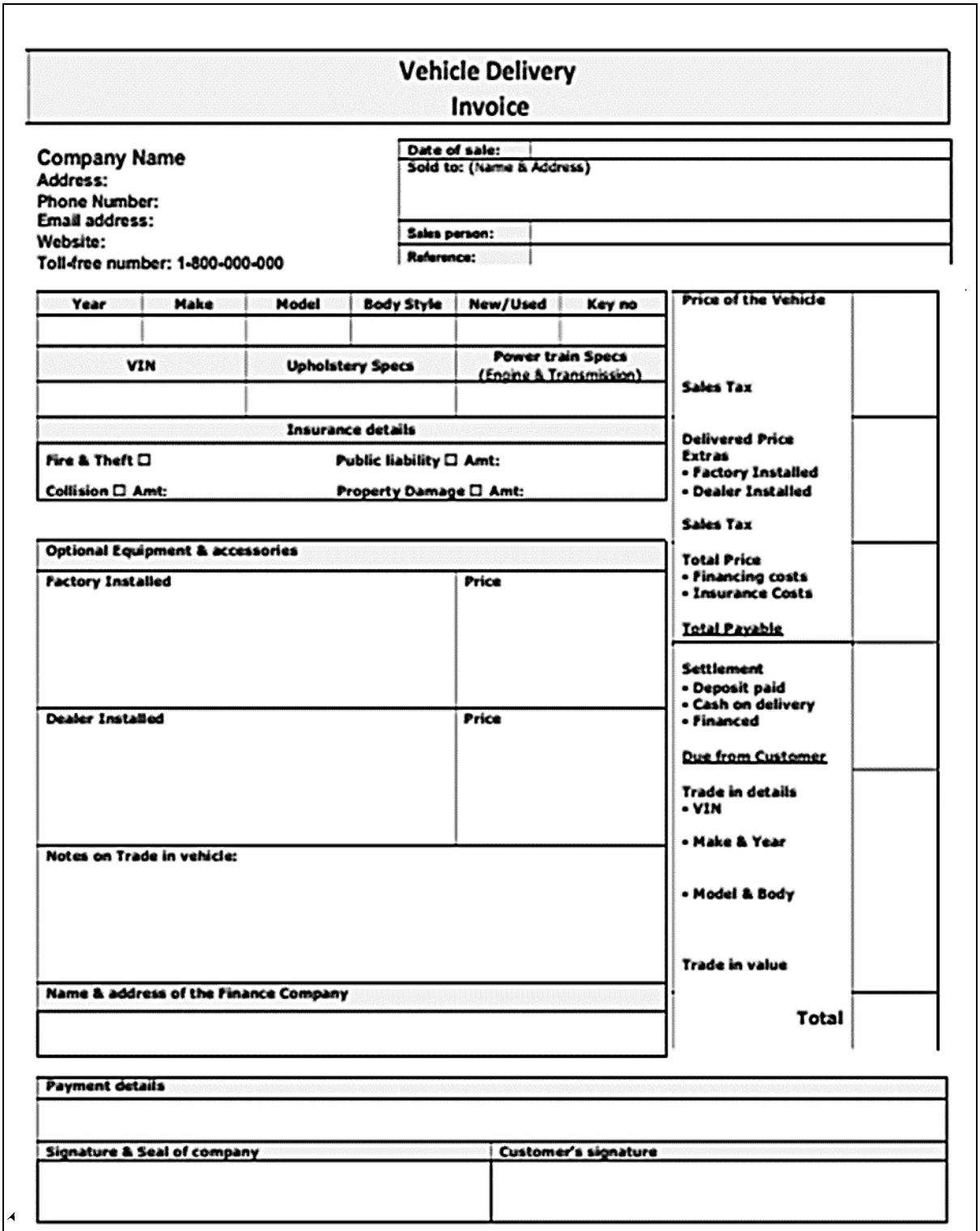
Invoicing vehicle deliveries and handling customer complaints are important aspects of running a successful business in the automotive industry. This provides insights and effective practices for invoicing vehicle deliveries accurately and efficiently, as well as managing customer complaints with professionalism and customer satisfaction in mind.

Invoicing Vehicle Delivery:

When a vehicle is delivered to a customer, it's important to create an invoice to record the transaction. The invoice should include the following information:

- Customer information: This includes the name, address, and contact information of the customer who purchased the vehicle.
- Vehicle information: This includes the make, model, year, and any other relevant details about the vehicle.
- Sales price: This is the price that the customer paid for the vehicle.

- Taxes and fees: This include any applicable taxes and fees associated with the sale.
- Payment terms: This includes the payment terms, such as the due date and any late payment fees.
- Warranty information: This includes any warranty information associated with the vehicle.
- Signature and date: The invoice should be signed by both the seller and the buyer, with the date of the transaction.



Vehicle Delivery Invoice

Company Name
Address:
Phone Number:
Email address:
Website:
Toll-free number: 1-800-000-000

Date of sale:
Sold to: (Name & Address)
Sales person:
Reference:

Year	Make	Model	Body Style	New/Used	Key no

VIN	Upholstery Specs	Power train Specs (Engine & Transmission)

Insurance details

Fire & Theft ☐ Public liability ☐ Amt:
Collision ☐ Amt: Property Damage ☐ Amt:

Optional Equipment & accessories

Factory Installed	Price

Dealer Installed	Price

Notes on Trade in vehicle:

Name & address of the Finance Company

Price of the Vehicle	
Sales Tax	
Delivered Price Extras • Factory Installed • Dealer Installed	
Sales Tax	
Total Price • Financing costs • Insurance Costs	
Total Payable	
Settlement • Deposit paid • Cash on delivery • Financed	
Due from Customer	
Trade in details • VIN • Make & Year • Model & Body	
Trade in value	
Total	

Payment details

Signature & Seal of company	Customer's signature

Fig. 5.10: Vehicle Delivery Invoice

Handling Complaints:

If a customer has a complaint about the vehicle or the service they received, it's important to handle the complaint in a timely and professional manner. Here are some steps to follow when handling complaints:

- Listen to the customer: Allow the customer to express their concerns and listen carefully to what they have to say.
- Apologise: If appropriate, apologise for any inconvenience or issues the customer has experienced.
- Investigate: Gather information about the complaint and investigate the issue to determine the cause
- Offer a solution: Offer a solution to the customer, such as a repair or replacement, that addresses their concerns.
- Follow up: Follow up with the customer to ensure that their issue has been resolved to their satisfaction.
- Learn from the experience: Use the complaint as an opportunity to learn and improve the service or product for future customers.

Handling complaints professionally and effectively can help to build trust and loyalty with customers, and can lead to improved business performance.

Check Your Progress

A. Fill in the Blanks:

1. When a vehicle is delivered to a customer, it's important to create an invoice to record the _____.
2. If a customer has a complaint about a vehicle or the service they received, it's important to handle the complaint in a timely and _____ manner.
3. Handling complaints professionally and effectively can help to build trust and loyalty with _____, and can lead to improved business performance

B. **Multiple Choice Questions:**

1. What information should be included in an invoice for vehicle delivery?

a) Customer information, vehicle information, sales pitch, and payment method.

b) Customer information, vehicle information, sales price, and warranty information.

c) Customer information, vehicle identification number (VIN), and maintenance history.

d) Customer information, vehicle information, and driving license details.

2. Why is it important to handle customer complaints professionally?

a) To avoid any further communication with the customer.

b) To demonstrate commitment to customer satisfaction and build trust.
c) To shift blame onto the customer and avoid responsibility.
d) To discourage customers from providing feedback.

3. What are the benefits of handling customer complaints effectively?
a) Improved business performance and reputation.
b) Increased customer complaints and negative reviews.
c) Higher prices for products and services.
d) Decreased customer loyalty and trust.

4. How can handling customer complaints contribute to customer loyalty?
a) By avoiding customer complaints altogether.
b) By offering monetary compensation for every complaint.
c) By actively listening to customers and addressing their concerns.
d) By disregarding customer complaints and focusing on new customers.

C. Answer the following Questions:

1. What information should be included in an invoice for vehicle delivery?
2. How should customer complaints be handled?
3. Why is it important to create an invoice for vehicle delivery?
4. Why is accurate and efficient invoicing for vehicle deliveries important in the automotive industry?
5. How can handling customer complaints effectively contribute to the success of an automotive business?
6. What are some best practices for handling customer complaints in the automotive industry?

Activity

1. Collect the various sources of information available for assessing service and repair requirements including service manual, diagnostic and visual displays put up in the workshop.
2. Discuss the analysed information and evaluate results to choose the best solution and solve problems

Session 5: Inspection and Testing of EV Components

The exact schedule may vary depending on the specific make and model of the Electric Vehicle, as well as the recommendations of the

manufacturer. Generally, the standard schedule for Electric Vehicle service may include regular maintenance tasks such as:

a) Battery system inspection and testing.
b) Brake system inspection and replacement, if needed.
c) Tire rotation and replacement, if needed.
d) Cabin air filter replacement.
e) Checking and replacing coolant and other fluids.
f) Cleaning and inspecting the charging port and cable.
g) Updating software and firmware as necessary.
h) Checking and replacing any damaged or worn-out parts.

It's important to follow the manufacturer's recommended service schedule to ensure the long-term health and reliability of the Electric Vehicle. Regular maintenance can also help prevent breakdowns and minimise repair costs.

The Safety Rules during servicing of vehicle to be followed:

You have visited the service station and seen that service technician is doing their work properly. During servicing of vehicle in a garage or service station the technician must follow some precautions and safety rules to prevent the accidents to occur, please observe whether safety rules are being followed or not. These safety rules are:

- Always select right tools for specific job. The wrong tool could damage the part being worked on and could cause you to get hurt.
- Keep your tools and equipment's under control.
- Wipe excess oil and grease off your hands and tools so that you can get a good grip on tools or parts.
- Work quietly and give full attention on your job.
- Keep jack handles out of the way. Stand the creeper against the wall when it is not in use.
- Do not put sharp objects, such as screw drivers, in your pocket. You could cut yourself or get stabbed, or you could damage the seat.
- Make sure that technician cloths are right for the job and he/she should wear full leather safety shoes.
- If oil, grease, or any liquid spills on the floor, clean it up so that no one will slip and fall.
- Always wear eye protection when using a grinding wheel or welding equipment or working with chemicals such as solvents.
- While using jack, place it properly to avoid slipping.

A. Battery system inspection and testing in Electric Vehicle

In Electric Vehicles, the battery system is a critical component that requires regular inspection and testing to ensure optimal performance and longevity. Here are some important aspects of battery system inspection and testing in Electric Vehicles:

- **Disconnect the battery**: Before starting the inspection and testing process, the battery needs to be disconnected to prevent any accidental electrical shocks. Battery system inspection and testing is an important maintenance task for Electric Vehicles, as it ensures the vehicle's performance and longevity.
- Here are the steps involved in the battery system inspection and testing process:
- **Visual inspection:** A visual inspection of the battery pack and all associated components can reveal any visible damage or signs of wear and tear. This includes checking for any physical damage to the battery casing, loose or corroded connections, or signs of leaking fluids.
- **Voltage check**: A voltage check of the battery pack can identify any cells or modules that may be underperforming or failing. This can be done using a multimeter or another specialised tool.
- **Capacity check**: A capacity check of the battery pack can identify any cells or modules that may have reduced capacity, which can impact the overall performance of the battery system. This can be done using specialised testing equipment.
- **Internal resistance checks**: An internal resistance check of the battery pack can identify any cells or modules that may have higher internal resistance, which can cause uneven charging and discharging of the battery system. This can be done using specialised testing equipment.
- **Thermal imaging**: Thermal imaging of the battery pack can identify any cells or modules that may be overheating or experiencing abnormal temperature fluctuations. This can be done using specialised cameras or equipment.
- **Reconnect the battery**: Once the inspection and testing process is complete, the battery can be reconnected.
- **Analyse results:** The results of the battery system inspection and testing can help identify any issues or areas of concern that may need to be addressed. Based on the results, further maintenance or repair actions may be necessary.

Fig. 5.11: Battery system inspection

1) **Visual Inspection:** A visual inspection of the battery pack can reveal any visible damage or signs of wear and tear. This includes checking for any physical damage to the battery pack, such as dents, cracks, or corrosion.
2) **Battery Management System (BMS) Diagnosis:** The BMS is responsible for managing the battery pack and ensuring its health and safety. A diagnostic test of the BMS can identify any potential issues or faults in the battery pack.
3) **State of Charge (SoC) and State of Health (SoH) Testing:** SoC testing measures the amount of charge remaining in the battery pack, while SoH testing evaluates the battery's overall health and performance. These tests can help identify any degradation or other issues that may impact the battery's performance.
4) **Capacity Testing:** Capacity testing evaluates the battery's ability to store and deliver energy. This test can help identify any loss of capacity or other issues that may impact the battery's performance.
5) **Environmental Testing:** Extreme temperatures, both hot and cold, can impact the performance and lifespan of Electric Vehicle batteries. Environmental testing can evaluate the battery's ability to withstand these extreme temperatures and identify any potential issues.

It's important to follow the manufacturer's recommended battery system inspection and testing schedule to ensure the long-term health and performance of the Electric Vehicle battery. Regular testing and maintenance can help prevent unexpected failures and costly repairs.

B. Brake system inspection and replacement in Electric Vehicle

In an Electric Vehicle, the brake system is responsible for slowing and stopping the vehicle. It's important to regularly inspect and replace brake components to ensure the safety and performance of the vehicle.

Step-by-Step procedure of Brake system inspection and replacement

Brake system inspection and replacement is an important maintenance task for Electric Vehicles, as it ensures the vehicle's safety and performance. Here are the steps involved in the brake system inspection and replacement process:

1) Raise the vehicle: The Electric Vehicle needs to be lifted off the ground to access the brake components. This is typically done using a hydraulic lift or jack.
2) Remove the wheels: The lug nuts are removed using a lug wrench or impact wrench, and the wheels are taken off the vehicle.
3) Visual inspection: A visual inspection of the brake pads, rotors, calipers, and other components can reveal any visible damage or signs of wear and tear. This includes checking for any physical damage to the brake system, such as cracks, corrosion, or warping.

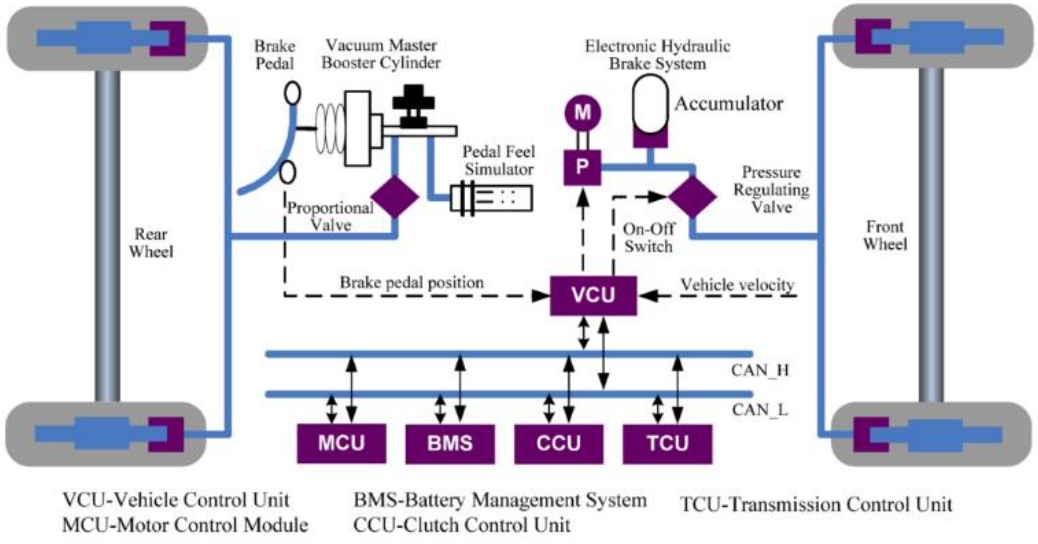


Fig. 5.12: Brake system inspection

4) Brake fluid check: Brake fluid is critical to the proper functioning of the brake system. A check of the brake fluid level and quality can identify any leaks or other issues that may impact the brake system's performance.

5) Brake pad thickness check: Brake pads wear down over time and require regular replacement. A check of the brake pad thickness can identify any worn or damaged pads that need to be replaced.
6) Brake rotor inspection: Brake rotors can warp or become damaged over time, which can impact the performance of the brake system. An inspection of the rotors can identify any issues that need to be addressed.
7) Brake Caliper inspection: The brake calipers are responsible for applying pressure to the brake pads, which in turn slow and stop the vehicle. An inspection of the calipers can identify any issues that may impact their ability to function properly.
8) Replacement of worn or damaged components: If any brake components are found to be worn or damaged during the inspection, they need to be replaced. This includes replacing brake pads, rotors, calipers, or other components as necessary.
9) Reassembly: Once any necessary replacements or repairs are made, the brake components are reassembled onto the vehicle.
10) Brake fluid bleeding: If any brake components were replaced, it may be necessary to bleed the brake system to remove any air bubbles that may have entered the system.
11) Lower the vehicle: Once the brake system inspection and replacement process are complete, the vehicle is lowered back down to the ground.

It's important to follow the manufacturer's recommended brake system inspection and replacement schedule to ensure the safety and performance of the Electric Vehicle. Regular inspections and maintenance can help prevent unexpected brake failures and costly repairs.

C. Tire rotation and replacement of Electric Vehicle, steps of procedure to replacement of Electric Vehicle

Tire rotation and replacement are important maintenance tasks for Electric Vehicles, as they can impact the vehicle's handling, performance, and safety. Here are the steps involved in the replacement of Electric Vehicle tires:

1) Lift the vehicle: The Electric Vehicle needs to be lifted off the ground to access the tires. This is typically done using a hydraulic lift or jack.

Fig. 5.13: Removal of the old tire

2) Remove the old tire: The lug nuts are removed using a lug wrench or impact wrench, and the old tire is taken off the vehicle.
3) Install the new tire: The new tire is mounted onto the rim and then secured onto the vehicle using lug nuts. The lug nuts are tightened to the manufacturer's recommended torque specifications.
4) Inflate the tire: The new tire is inflated to the manufacturer's recommended tire pressure, which is typically found on a sticker located on the driver's side door jamb or in the owner's manual.
5) Lower the vehicle: Once the new tire is installed and inflated, the vehicle is lowered back down to the ground.

Fig. 5.14: Tire rotation and replacement

In terms of tire rotation, the procedure involves moving the tires from one position to another on the vehicle to ensure even wear and prolong the life of the tires. The specific rotation pattern may vary depending on the make and model of the Electric Vehicle, but generally involves

moving the front tires to the rear and vice versa, or rotating the tires diagonally.

D. CABIN AIR FILTER

Cabin air filter replacement is an important maintenance task for Electric Vehicles, as it ensures the air inside the vehicle cabin is clean and free of contaminants. Here are the steps involved in the cabin air filter replacement process of an Electric Vehicle:

i. Open the glove compartment: Open the glove compartment in the Electric Vehicle by pressing the release button or lever.
ii. Remove the damper: If the glove compartment has a damper, remove it by pressing the tabs on either side and pulling it out.
iii. Locate the cabin air filter: The cabin air filter is usually located behind the glove compartment. Consult the owner's manual or a repair manual for the specific location of the cabin air filter.
iv. Remove the cabin air filter cover: If the cabin air filter is covered, remove the cover by pressing the tabs or screws that secure it in place.
v. Remove the old cabin air filter: Slide the old cabin air filter out of its housing and dispose of it properly.
vi. Inspect the old cabin air filter: A visual inspection of the old cabin air filter can reveal any signs of wear and tear or contaminants that have accumulated on the filter.
vii. Clean the filter housing: Use a soft brush or vacuum cleaner to remove any debris or contaminants that may have accumulated inside the filter housing.
viii. Install the new cabin air filter: Insert the new cabin air filter into the filter housing, making sure to align it properly with the arrows or markings on the filter.
ix. Reattach the cabin air filter cover: Reattach the cabin air filter cover by pressing the tabs or screws that secure it in place.
x. Replace the damper: If the glove compartment has a damper, reattach it by pushing it into place until it clicks.
xi. Close the glove compartment: Close the glove compartment by pressing it until it latches securely.
xii. Test the new cabin air filter: Test the air conditioning and heating system to ensure that the new filter is working properly.

Fig. 5.15: Cabin Air Filter

It's important to follow the manufacturer's recommended cabin air filter replacement schedule to ensure the air inside the Electric Vehicle cabin is clean and free of contaminants. Regular replacement of the cabin air filter can also improve the performance and efficiency of the heating and cooling systems in the Electric Vehicle.

E. Coolant and other fluids in an EV:

Checking and replacing fluids is an important aspect of Electric Vehicle maintenance. Here are the steps involved in checking and replacing then consult the owner's manual:

i. **Check the coolant level:** The coolant reservoir is usually located under the hood of the Electric Vehicle. Check the coolant level by looking at the markings on the reservoir. If the level is low, add coolant to the reservoir until it reaches the recommended level.

ii. **Check the brake fluid level:** The brake fluid reservoir is usually located near the brake pedal or under the hood. Check the brake fluid level by looking at the markings on the reservoir. If the level is low, add brake fluid to the reservoir until it reaches the recommended level.

iii. **Check the windshield washer fluid level:** The windshield washer fluid reservoir is usually located under the hood of the Electric Vehicle. Check the fluid level by looking at the markings on the reservoir. If the level is low, add windshield washer fluid to the reservoir until it reaches the recommended level.

iv. **Check the power steering fluid level:** The power steering fluid reservoir is usually located under the hood of the Electric Vehicle. Check the fluid level by looking at the markings on the reservoir. If the level is low, add power steering fluid to the reservoir until it reaches the recommended level.

v. **Replace the coolant:** Over time, the coolant in the Electric Vehicle may become contaminated or lose its effectiveness. Refer to the owner's manual for the recommended replacement interval and procedure for replacing the coolant.

vi. **Replace other fluids as necessary**: Brake fluid, windshield washer fluid, and power steering fluid may also need to be replaced periodically. Refer to the owner's manual for the recommended replacement interval and procedure for replacing these fluids.

The owner's manual will provide information on the location of the coolant reservoir and other fluid reservoirs, as well as the type of coolant and fluids recommended by the manufacturer.

Fig. 5.16: coolant and other fluids

F. Cleaning and inspecting the charging port and cable in EV

Here is the step-by-step process of cleaning and inspecting the charging port and cable in an Electric Vehicle:

- Turn off the Electric Vehicle and disconnect the charging cable from the charging port.
- Inspect the charging cable for any visible damage such as cuts, frayed wires, or bent pins. If you notice any damage, do not use the cable and replace it immediately.
- Next, inspect the charging port of the Electric Vehicle for any debris, dust, or dirt buildup. You can use a flashlight to inspect the inside of the port.
- If you notice any debris inside the port, use a soft-bristled brush or compressed air to remove the dirt buildup gently. Avoid using sharp objects or liquids to clean the port.
- You can also use a microfiber cloth to wipe the charging cable and the charging port of the Electric Vehicle.

- Once you have finished cleaning, reinspect the charging cable and port for any damage or debris.
- Finally, plug the charging cable back into the charging port of the Electric Vehicle and turn on the power. Ensure that the cable is securely attached to the port.

By following these steps, you can ensure that the charging port and cable of your Electric Vehicle are clean and in good condition, which will help maintain the performance and longevity of your vehicle's battery.

Check your Progress

A) Fill in the Blanks:

1) Before starting the inspection and testing process, the battery needs to be _____ to prevent any accidental electrical shocks.
2) The _____ will provide information on the location of the coolant reservoir and other fluid reservoirs.
3) Regular replacement of the cabin air filter can also improve the _____ and efficiency of the heating and cooling systems in the Electric Vehicle.
4) Regular inspections and maintenance can help prevent unexpected brake downs _____ and costly repairs

B) Multiple Choice Questions:

1. What is the first step in the battery system inspection and testing process?
a) Voltage check
b) Visual inspection
c) Capacity check
d) Thermal imaging

2. Which tool can be used to check the voltage of the battery pack in an Electric Vehicle?
a) Multimeter
b) Thermal camera
c) Specialised testing equipment
d) Visual inspection

3. What does capacity check in the battery system inspection and testing process evaluate?
a) Physical damage to the battery pack
b) Voltage of the battery pack

c) The battery's ability to store and deliver energy
d) Internal resistance of the battery pack

4. What should be done once the battery system inspection and testing process is complete?
a) Analyse the results
b) Reconnect the battery
c) Replace the battery pack
d) Repeat the inspection and testing process

C) Short Answer Questions:

1) Describe the importance of battery system inspection and testing in Electric Vehicles and explain the steps involved in the process.
2) Provide a detailed step-by-step procedure for brake system inspection and replacement in Electric Vehicles.
3) Explain the importance of checking and replacing coolant and other fluids in Electric Vehicles and outline the steps involved in the process.
Discuss the procedure for cleaning and inspecting the charging port and cable in Electric Vehicles, highlighting its significance.

Activity

1. Demonstrate how to support an Electric Vehicle service technician during diagnosing faults in the subassembly, and electric and electronic components of EV.
2. Draw the flow chart of the service layout for Electric Vehicle Maintenance.

Session 6: Safety of The High-Voltage System

In recent years, Electric Vehicles (EVs) have become increasingly popular due to their environmental advantages and technological advancements. A vital component of EVs is the high-voltage system, which plays a crucial role in powering the vehicle and ensuring optimal performance. In this unit we will discuss the complexity of the high-voltage system in EVs, including its components, functions, and its impact on the overall driving experience.

- **Understanding the High-Voltage System**

The high-voltage system in an EV consists of several key elements that work together to efficiently propel the vehicle. These components include

the battery pack, power electronics, electric motor, and charging infrastructure.

- Battery Pack

  At the core of the high-voltage system lies the battery pack, which stores and supplies electrical energy to power the electric motor. Advanced lithium-ion batteries are commonly used in EVs due to their high energy density and long lifespan. The capacity of the battery pack directly affects the driving range of the vehicle, and continuous advancements in battery technology are extending this range, making EVs more practical for everyday use.

- Power Electronics

  The power electronics in an EV are responsible for managing the flow of electrical energy between the battery pack, electric motor, and other vehicle systems. They ensure efficient power conversion and control, enabling smooth acceleration, regenerative braking, and overall energy optimisation. Advanced power electronics also contribute significantly to enhancing the vehicle's performance and safety.

- Electric Motor

  The electric motor in an EV converts electrical energy into mechanical energy, providing the necessary torque to drive the wheels. Electric motors offer instant torque delivery, resulting in quick acceleration and a responsive driving experience when compared to internal combustion engines. The high-voltage system supplies power to the electric motor, enabling it to efficiently propel the vehicle while reducing its environmental impact.

- Charging Infrastructure

  To keep an EV powered and ready for the road, a robust charging infrastructure is essential. Charging stations equipped with high-voltage capabilities allow EV owners to quickly recharge their vehicles. Fast-changing technologies, such as DC fast charging, can replenish the battery pack to a significant level within minutes, providing convenience and minimising charging downtime.

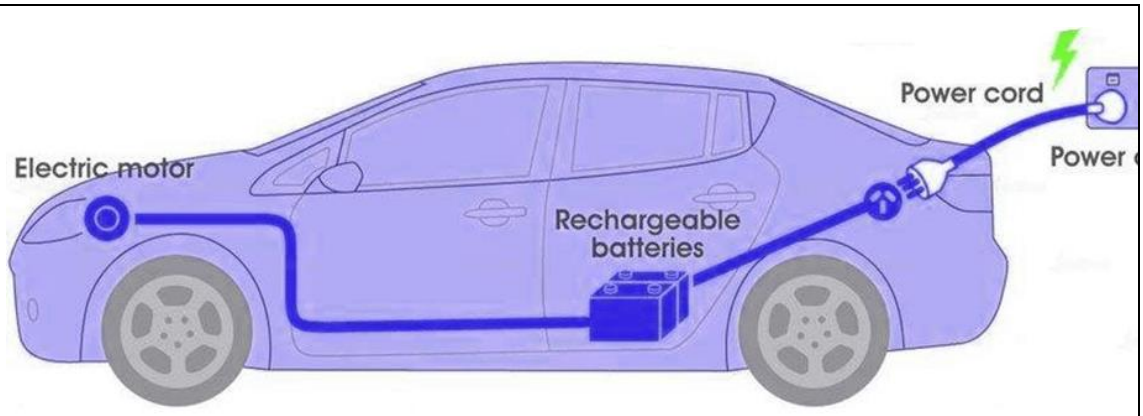


Fig. 5.17: Charging Infrastructure

Advantages of the High-Voltage System

The integration of a high-voltage system in EVs brings numerous advantages, contributing to the global adoption of Electric Vehicles.

- Improved Performance

  The high-voltage system, combined with advanced power electronics and electric motors, offers superior performance compared to traditional internal combustion engines. EVs equipped with high-voltage systems can deliver impressive acceleration, smooth power delivery, and precise control, resulting in an exhilarating driving experience.

- Environmental Benefits

  The primary motivation behind the development of EVs is their reduced environmental impact. The high-voltage system, powered by electricity, produces zero tailpipe emissions, significantly reducing greenhouse gas emissions and air pollution. Transitioning from fossil fuel-powered vehicles to EVs can make substantial progress in mitigating climate change and improving air quality.

- Energy Efficiency

  EVs equipped with high-voltage systems are known for their energy efficiency. The power electronics and electric motors in these vehicles convert electrical energy with high efficiency, minimising energy losses and maximising the utilisation of stored power. This efficiency

contributes to a longer driving ranges and improved overall energy consumption.

- Lower Operating Costs

  Although the initial purchase price of an EV may be higher than that of a conventional vehicle, the operating costs over the vehicle's lifetime are generally lower. High-voltage systems enable EVs to benefit from lower energy costs and reduced maintenance requirements since electric motors have fewer moving parts compared to internal combustion engines. Additionally, government incentives and decreasing battery costs further contribute to the cost-effectiveness of EVs.

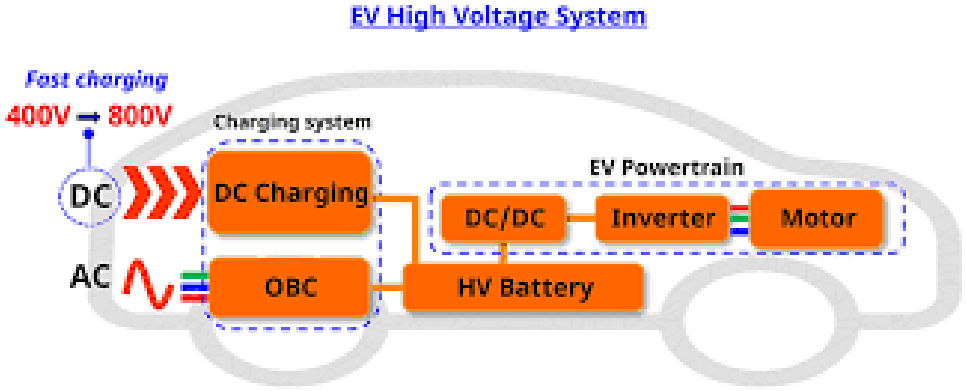


Fig. 5.18: High-Voltage System

SAFETY PREACAUTIONS

The high-voltage system in Electric Vehicles (EVs) plays a major role in powering the vehicle and ensuring its optimal performance. However, it is essential to prioritise safety when it comes to handling and working on the high-voltage system. In this part, we will discuss important safety precautions and guidelines followed to minimize the risk of accidents or injuries related to the high-voltage system.

- **Avoid Unauthorised Modifications and Work**

  It is crucial to refrain from performing any modifications or work on the vehicle, especially maintenance and repair work on the high-voltage system and the body. Unauthorised modifications or repairs can lead to serious safety hazards, including the risk of fire and fatal electrocution.

The high-voltage system is complex and requires specialised knowledge and equipment to handle properly.

- **Seek Professional Assistance**
  When modifications or work are required on the vehicle, it is important to have them performed by an authorised EV service center or one that operates according to the manufacturer's specifications. These service centers have trained personnel who possess the necessary expertise and experience in working with high-voltage systems. Entrusting the work to professionals ensures that the modifications or repairs are carried out safely and effectively.

- **Maintain the Integrity of the High-Voltage System**
  The high-voltage system in an EV is designed as a self-contained system, ensuring safety as long as no unauthorised work is performed on the high-voltage electrical components or the chassis. It is essential to respect the integrity of the system and avoid any tampering or unauthorised modifications that could compromise its safety features.

- **Follow Safety Guidelines and Procedures**
  When working on or near the high-voltage system, it is crucial to follow established safety guidelines and procedures. These may include wearing appropriate Personal Protective Equipment (PPE) such as insulated gloves and safety glasses, ensuring proper grounding of the vehicle, and adhering to lockout/tagout procedures to prevent accidental energisation of the high-voltage system.

- **Stay Informed and Educated**
  As an EV owner or operator, it is important to stay informed and educated about the safety considerations related to the high-voltage system. Keep up with the latest guidelines, safety bulletins, and recommendations provided by the vehicle manufacturer and authorised service centers. This knowledge will help you make informed decisions and take necessary precautions to ensure the safety of yourself and others.

The safety of the high-voltage system in Electric Vehicles is of paramount importance. It is vital to avoid unauthorised modifications or work, seek professional assistance from authorised service centers, and maintain the integrity of the high-voltage system. By following safety guidelines and staying informed, EV owners can minimise the risks associated with the high-voltage system and enjoy the benefits of electric mobility with peace of mind.

Check Your Progress

A. Fill in the Blanks:

1) The high-voltage system in an EV include the _____, power electronics, electric motor, and charging infrastructure.
2) The primary motivation behind the development of EVs is their reduced _____ impact.
3) The _____ is complex and requires specialised knowledge and equipment to handle properly.
4) The service centers have _____ personnel who possess the necessary expertise and experience in working with high-voltage systems

B. Multiple Choice Questions:

1. Which of the following components are included in the high-voltage system of an Electric Vehicle (EV)?
A) Engine, transmission, and exhaust system
B) Battery pack, power electronics, electric motor, and charging infrastructure
C) Radiator, fuel tank, and fuel injectors
D) Steering wheel, brakes, and suspension system

2: What is the role of the battery pack in the high-voltage system of an EV?
A) It converts electrical energy into mechanical energy.
B) It manages the flow of electrical energy between the battery pack and electric motor.
C) It stores and supplies electrical energy to power the electric motor.
D) It ensures efficient power conversion and control in the high-voltage system.

3: Which component of the high-voltage system is responsible for converting electrical energy into mechanical energy in an EV?

A) Battery pack
B) Power electronics
C) Electric motor
D) Charging infrastructure

4. EVs generally considered to have lower operating costs compared to conventional vehicles
A) They have lower energy costs and reduced maintenance requirements.
B) They offer longer driving ranges and improved overall energy consumption.
C) They deliver instant torque and quick acceleration.
D) They contribute to reduced greenhouse gas emissions and air pollution.

Answer the following Questions:

1. What are the key components of the high-voltage system in an Electric Vehicle?
2. What are some advantages of integrating a high-voltage system in EVs?
3. What is the significance of maintaining the integrity of the high-voltage system in an EV?
4. What safety guidelines and procedures should be followed when working on or near the high-voltage system of an EV?

Activity

1. Make a flow chart to work on the HV systems that do not require isolation, troubleshooting and replacing parts on the active HV system.

Module 6	Health and Safety Equipment

Module Overview

Electric Vehicles are High-Voltage systems to operate, which presents different types of risks battery heat (causes fire explosion) and High-Voltage Systems (causes Electric shock). Electric Vehicles require specialised maintenance to keep them running efficiently and safely.

Learning Outcome

After completion of this module, you will be able to:

- Understand and explain the unique safety considerations specific to electric vehicles, including high-voltage systems and battery hazards.
- Identify and describe potential risks and hazards associated with electric vehicle maintenance and operation.
- Demonstrate knowledge of emergency response procedures in case of an accident or electrical fault involving an electric vehicle.
- Identify and describe the types of personal protective equipment (PPE) required when working with electric vehicles.
- Understand the proper use and maintenance of PPE to ensure maximum protection.

Module Structure

Session 1: Safety Consideration for Electric Vehicles
Session 2: Personal Protective Equipment

Session 1: Safety Consideration for Electric Vehicles

Electric Vehicles (EVs) are a promising technology for reducing greenhouse gas emissions and improving air quality, but they also require careful safety considerations to ensure that they are safe for passengers, pedestrians, and the environment. Here are some of the key safety considerations for Electric Vehicles:

1) **Battery Safety:** The battery is one of the most critical components of an Electric Vehicle, and safety considerations must be taken to prevent thermal runaway, a condition in which the battery overheats and causes a fire or explosion. EV manufacturers use various measures to prevent

thermal runaway, such as cooling systems, thermal management systems, and safety sensors.

2) **Electrical Safety:** Electric Vehicles require high-voltage systems to operate, which presents the risk of electrical shock. EV manufacturers implement multiple layers of protection, including high-voltage isolation, grounding, and fail-safes, to ensure that passengers and maintenance personnel are safe from electrical hazards.
3) **Crash Safety:** Electric Vehicles are designed with safety in mind, just like conventional vehicles. In the event of a crash, EVs must be designed to protect the occupants, maintain battery integrity, and prevent fires or other hazards.
4) **Charging Safety:** Charging an EV requires high-voltage electricity, which presents the risk of electrical shock and fire. EV manufacturers provide safety guidelines for charging, and charging infrastructure providers must comply with safety standards to prevent accidents.
5) **Environmental Safety**: Electric Vehicles are generally cleaner than conventional vehicles, but their batteries require careful handling and disposal to prevent environmental damage. Manufacturers and governments are implementing policies to ensure that EV batteries are recycled or disposed of re Maintenance Safety: Electric Vehicles require specialised maintenance to keep them running efficiently and safely. Maintenance personnel must be trained in high-voltage electrical systems and the proper handling of batteries to prevent accidents and ensure proper functioning.
6) **Pedestrian Safety**: Electric Vehicles operate quietly, which can make them difficult to hear for pedestrians, particularly those with visual impairments. To address this issue, EV manufacturers are required to install acoustic warning systems to alert pedestrians of an approaching vehicle.
7) **Fire Safety:** Although Electric Vehicles are generally safe, fires can occur in the event of a severe crash or malfunction. EV manufacturers use fire-resistant materials and safety features to minimise the risk of fires and ensure that occupants have enough time to evacuate in the event of an emergency.
8) **Cybersecurity:** As Electric Vehicles become more connected and autonomous, there is a growing concern for cybersecurity. EV manufacturers must take steps to protect against hacking and unauthorised access to the vehicle's systems, which could pose a safety risk to passengers and other road users.
9) **Weather-related Safety:** Electric Vehicles are subject to the same weather-related risks as conventional vehicles, such as reduced visibility, slick roads, and high winds. However, EVs may also

experience reduced range and performance in extreme temperatures. EV manufacturers provide guidelines for safe operation in adverse weather conditions to ensure that drivers are prepared and can operate the vehicle safely.

10) **Emergency Response:** Emergency responders may face unique challenges when responding to accidents involving Electric Vehicles. They must be trained to handle high-voltage systems and to assess the risks of thermal runaway or other hazards. EV manufacturers provide guidance and training to emergency responders to ensure that they can respond quickly and safely in the event of an emergency.

11) **Supply Chain Safety:** The production and disposal of EV batteries require the use of hazardous materials, which can pose risks to workers and the environment if not handled properly. EV manufacturers must ensure that their supply chain partners comply with safety regulations and ethical labour practices to prevent accidents and minimise environmental damage.

Working on an Electric Vehicle (EV) requires special safety considerations due to its high-voltage electrical system. Here are some important safety precautions to follow when working on an EV:

1) Power Off: Before working on an EV, ensure that the power is off and the vehicle is not charging. Disconnect the negative battery cable to prevent accidental electrical shock.
2) Lockout/Tagout: Use a lockout/tagout procedure to prevent the power from being turned on accidentally. Lockout/tagout devices should be applied to the power switch and any other electrical components that could potentially be energised.
3) Vehicle Positioning: Position the vehicle on a level surface and secure it with wheel chocks to prevent it from moving during the repair process.
4) Special Tools: Use only tools that are designed for use with high-voltage electrical systems and ensure that they are in good condition.
5) Repair Manuals: Refer to the manufacturer's repair manuals for specific instructions on working on the EV. Follow all safety procedures outlined in the manual.
6) Fire Extinguisher: Have a fire extinguisher nearby and know how to use it in case of an electrical fire.
7) Trained Personnel: Only trained and qualified personnel should work on an EV. If you are not qualified to work on high-voltage electrical systems, do not attempt to do so.

Check Your Progress

1. **Fill in the Blanks:**

1) EV manufacturers use various measures to prevent _____ runaway, such as cooling systems, thermal management systems, and safety sensors.
2) Before working on an _____, ensure that the power is off and the vehicle is not charging.
3) Have a fire extinguisher nearby and know how to use it in case of an _____.
4) Vehicle Positioning: Position the vehicle on a level surface and secure it with _____ to prevent it from moving during the repair process.

B. Multiple Choice Questions:

1. What is the most critical component of an Electric Vehicle that requires careful safety considerations?
a) Cooling system
b) Battery
c) Electrical system
d) Charging infrastructure

2. What is the risk associated with high-voltage systems in Electric Vehicles?
a) Fire
b) Explosion
c) Electrical shock
d) Environmental damage

3. What is a potential risk during the charging of an Electric Vehicle?
a) Reduced range
b) Weather-related hazards
c) Cybersecurity threats
d) Electrical shock and fire

4. What safety concern arises with the increasing connectivity and autonomy of Electric Vehicles?
a) Battery disposal
b) Weather-related risks
c) Emergency response challenges
d) Cybersecurity threats

C. Answer the following questions

1) What are the key safety considerations for Electric Vehicles?

2) What are the safety guidelines for charging Electric Vehicles?
3) How do Electric Vehicle manufacturers address pedestrian safety concerns?
4) What challenges do emergency responders face when handling accidents involving Electric Vehicles?
5) What safety regulations and ethical labor practices should EV manufacturers ensure in their supply chain?

Activity

1. Make a list of safety aspect and safety tools.
2. Write the Functions of the different service equipment used in workshop with safety Precautions.

Session 2: Personal Protective Equipment

PPE means Personal Protective Equipment or equipment you use to guarantee your (own) safety. Use PPE always and anywhere where necessary. Observe the instructions for use, maintain them well and check regularly if they still offer sufficient protection. PPE refers to the equipment which protects the user from health hazards or safety risks at work. It includes Safety Shoes, Safety Helmets, foot wear, goggles etc. Personal Protective Equipment should be provided to all employees who are exposed to safety and health risks at work. In the automobile industry, workers frequently move from one work place to another and perform a variety of tasks. The employee should be trained on how and when to use protective equipment. Here are some of the PPE items that should be included in a typical kit for workers in an Electric Vehicle workshop:

1. Safety for The Head

Wearing a helmet offers protection and can prevent head injuries. Select a sturdy helmet that is adapted to the working conditions. These days you can find many elegant designs and you can choose extra options such as an adjustable interior harness and comfortable sweatbands. While working on an Electric Vehicle your helmet should be insulted.

Fig. 6.1: Safety for The Head

2. Protect Your Eyes

The eyes are the most complex and fragile parts of our body. Each day, more than 600 people worldwide sustain eye injuries during their work. Thanks to a good pair of safety glasses, these injuries could be prevented. Do you come into contact with bright light or infrared radiation? Then welding goggles or a shield offers the ideal protection! Electric Vehicle workshops involve working with a variety of hazardous materials and equipment, including chemicals, saws, and grinders. Safety glasses provide protection for the eyes against flying debris, dust, and other particles.

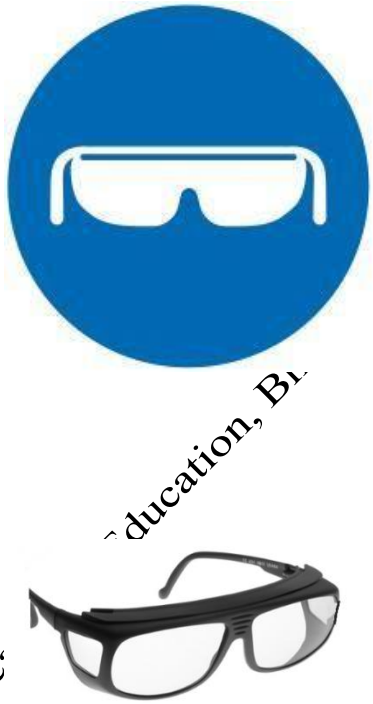


Fig. 6.2: Protect Your Eyes

Eye Protection

Protecting the eyes is extremely important because even a minor accident can cause long-term eye damage or even blindness. Here are several of the most common types of eye protection equipment:

Goggles - Simple safety goggles provide a strong layer of protection to the eyes. This is good for preventing objects from flying into the eyes such as sawdust, stones, and shards of glass.

Welding Masks - While welding masks sometimes cover the entire face, their main function is to protect the eyes from the extremely bright light of a torch. These masks are darkened significantly to prevent the

light from reaching and damaging the eyes.

Sunglasses - This is a simple type of PPE that most people never give a second thought. If you're regularly working in the sun or around bright lights, wearing sunglasses can help prevent many eye conditions down the road.

3. Hearing Protection

Do you work in an environment with high sound levels? In that case it is very important to consider hearing protection. Earplugs are very comfortable, but earmuffs are convenient on the work floor as you can quickly put these on or take them off.

Ear Plugs - Ear plugs are easy to use and provide a fair amount of protection by preventing loud noises from entering the ear at all.

Ear Muffs - Ear muffs go over the entire ear, and when worn properly, can provide a significant amount of noise reduction.

Electronic Ear Muffs - These advanced hearing protection devices work like ear muffs to stop the noise from coming in, but also have an electronic microphone that picks up voices and other noises and then plays them into the ear so people can still hear. The sounds are played at a low level so they do not cause damage.

Fig. 6.3: Hearing Protection

4. Maintain a Good Respiration

Respirators

Respirators are a type of personal protective equipment designed specifically to protect the lungs of the people wearing them. They can help filter out dust, debris, chemicals, and many other potential dangers. There are many types of respirators used for PPE, including:

Fig. 6.4: Respirator

Basic Facemask - A facemask can minimise the risk of exposure to simple biological contaminants, dust, debris, and other harmful impurities in the air. In a pinch, even a simple handkerchief could serve as a facemask (though not recommended for regular use).

Filtered Respirator - If there are known impurities that can cause serious damage or illness, having a filter on the respirator is important. There are many types of filtered respirators available depending on how many impurities need to be removed.

Self-Contained Breathing Apparatus - In situations where the air is extremely toxic, a self-contained breathing apparatus allows the employee to bring a supply of fresh air with them. This is also used when there is no oxygen to breath, such as under water.

Wearing a mask at work is no luxury, definitely not when coming into contact with hazardous materials. 15% of the employees within the EU inhale vapours, smoke, powder or dusk while performing their job. Dust masks offer protection against fine dust and other dangerous particles. If the materials are truly toxic, use a full-face mask. This adheres tightly to the face, to protect the nose and mouth against harmful pollution.

5. Protect Your Hands with The Right Gloves

Gloves are important PPE for Electric Vehicle workshops, as they protect the hands from cuts, punctures, and chemical exposure. Nitrile gloves are a good choice, as they are resistant to many chemicals commonly used in Electric Vehicle maintenance.

Hands and fingers are often injured, so it is vital to protect them properly. Depending on the sector you work in, you can choose from gloves for different applications:

- Protection against vibrations
- Protection against cuts by sharp materials
- Protection against cold or heat
- Protection against bacteriological risks
- Protection against splashes from diluted chemicals.

Plastic Gloves - Plastic (or latex) gloves are among the most common types of skin protection equipment. They can keep a wide range of hazards away, including biological and chemical solutions.

Cut-Resistant Gloves - Employees who work with sharp objects should wear cut-resistant gloves. These gloves are made of special materials that prevent blades from slicing through them.

Fig. 6.5: Protect Your Hands with The Right Gloves

6. Skin and Body Protection Equipment

Many chemicals and other materials can cause serious injuries or illnesses when they come in contact with the skin. When working with these hazards, having proper personal protective equipment is extremely important.

Protective Clothing - The most common type of skin protection equipment is general protective clothing. Something as simple as a lab coat helps reduce the risk of getting splashed with potentially hazardous solutions. While it isn't a high level of protection, yet it is sufficient for many situations.

Fig. 6.6: Wear the Correct Work Clothing

Heat-Resistant Clothing - When working with fire or other high temperature hazards, employees should wear heat-resistant clothing. This could be heat-resistant gloves or it could be an entire suit, depending on the situation. Preventing accidents is crucial in a crowded workshop. That is why a good visibility at work is a must: a high-visibility jacket and pants made of a strong fabric can help prevent accidents. Just like the hand protection, there are versions for different applications.

Electricity-Resistant Clothing - When working with or around high voltage areas, having PPE that can reduce the risk of electrical shock is essential. This could be rubber boots, gloves, or an entire body suit.

Face Shields - Face shields reduce the risk of having something splash up into the face, causing damage. Whether working with hot items,

corrosive materials, or biological materials, face shields can protect one of the most vulnerable parts of the body.

Hard Hats - Hard hats are a great way to keep someone's head safe when working in an area where something could fall on it.

7. Protection for The Feet

Fig.6.7: Protection for The Feet

Even your feet need solid protection. Safety shoes (type Sb, S1, S2 or S3) and boots (type S4 or S5) are the ideal solution to protect the feet against heavy weights. An antiskid sole is useful when working in a damp environment, definitely if you know that 16.2% of all industrial accidents are caused by tripping or sliding. On slippery surfaces, such as snow and ice, shoe claws are recommended. Special socks can provide extra comfort.

Worst-Case Scenario

Prevention is better than cure. A smart thing is to be prepared for the worst. A classic first-aid kit is no luxury but a first-aid kit for the eyes can also be an essential first aid. If the employee comes into contact with chemicals, a safety shower is mandatory, so that he/she can rinse the substances off his/her body at any moment.

Electrical Insulating Matting

Electrical insulating matting is a type of flooring material that is designed to provide insulation and protection against electric shock in areas where electrical equipment is present. These mats are commonly used in Electric Vehicle workshops, where workers may come into contact with electrical components and systems. Here are some key features and benefits of electrical insulating matting:

Electrical insulation: Electrical insulating matting is made from materials that have high dielectric strength, which means they are able

to resist the flow of electrical current. This makes them an effective barrier against electric shock.

Non-conductive: Electrical insulating matting is non-conductive, which means it does not conduct electricity. This is important in Electric Vehicle workshops, where workers may accidentally drop tools or other conductive materials onto the floor.

Durability: Electrical insulating matting is designed to be durable and long-lasting, even in harsh environments. It is resistant to abrasion, chemicals, and oil, making it ideal for use in busy workshops.

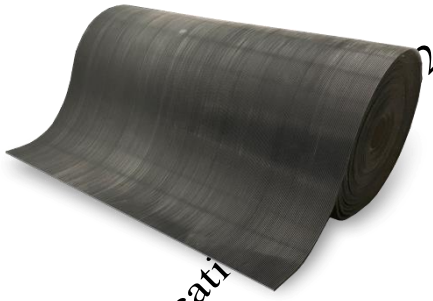


Fig. 6.8: Electrical insulating matting

Slip-resistant: Many types of electrical insulating matting have a slip-resistant surface, which helps to reduce the risk of slips and falls in the workshop.

Customisable: Electrical insulating matting is available in a range of sizes and thicknesses, making it easy to customise to the specific needs of the workshop.

Compliance: Electrical insulating matting is required to comply with various safety standards and regulations such as ASTM D178 and IEC 61111. This ensures that the matting provides effective protection against electric shock and other hazards.

Fig. 6.9: Insulated Rescue Sticks

Insulated rescue sticks: These are long, insulated poles that are used to safely disconnect the battery or other electrical components of an Electric Vehicle. They are typically made from fiberglass or other non-conductive materials to prevent electric shock.

Check Your Progress

A) Fill in the Blanks:

1) PPE means _____ or equipment you use to guarantee your (own) safety.
2) Wearing a helmet offers protection and can prevent _____ injuries.
3) Employees who work with sharp objects should wear _____ gloves.
4) Electrical insulating _____ is made from materials that have high dielectric strength, which means they are able to resist the flow of electrical current.

B) Multiple Choice Questions

1. Which of the following is considered Personal Protective Equipment (PPE)?

a) Safety glasses
b) Safety shoes
c) Earplugs
d) All of the above

2. What is the purpose of wearing a helmet in an Electric Vehicle workshop?

a) To protect the head from injuries
b) To keep the head cool
c) To improve visibility
d) To comply with workplace regulations

3. What is the purpose of hearing protection in a high sound level environment?

a) To improve communication with co-workers
b) To block out all sound
c) To reduce the risk of hearing damage
d) To comply with workplace regulations

4. What is the purpose of wearing heat-resistant clothing in a workshop?

a) To protect against cold temperatures
b) To protect against heat and fire hazards
c) To improve visibility
d) To comply with workplace regulations

5. What are insulated rescue sticks used for in an Electric Vehicle workshop?

a) To protect the eyes from chemicals
b) To safely disconnect the battery or electrical components
c) To provide insulation for hands and fingers
d) To comply with workplace regulations

C) Answer the following questions

1. What are some key features of electrical insulating matting?
2. What are insulated rescue sticks used for in an Electric Vehicle workshop?
3. What is the importance of Personal Protective Equipment (PPE) in ensuring safety in the workplace, and what are some guidelines for its use and maintenance?
4. What are the considerations for hand protection in an Electric Vehicle workshop, and what types of gloves, such as plastic gloves and cut-resistant gloves, are suitable for different applications?

Activity

1. Demonstrate the Personal Protective Equipment Kit.
2. Demonstrate the correct way of wearing and removing PPE such as face masks, hand gloves, face shields, PPE suits, etc.

Answer Key

Module 1: Introduction of Electric Vehicles in India

Session 1: History of Electric Vehicle

A) Fill in The Blanks	1. Electric Vehicle (EV)	2. Robert Anderson,
B) Multiple Choice Questions	1. B	2. C
	3. C	4. A
	5. B	

Session 2: The Environmental Impact and Electric Vehicles

A) Fill in The Blanks	1. Combustion	2. Electric Vehicles
	3. Emissions	4. Hydrocarbons.
B) Multiple Choice Questions	1. B	2. A
	3. A	4.
	5. A	

Session 3: Electric Vehicle Scenario in India

A) Fill in The Blanks	1. Electric Vehicle	2. 2015
B) Multiple Choice Questions	1. A	2. D
	3. A	4. B
	5. C	6. C

Session 4: Role and Duties of EV Service Assistant

A) Multiple Choice Questions	1. A	2. C
	3. B	4. D

Module 2: Electric Vehicles and their Components

Session 1: Types of Electric Vehicles

A) Fill in The Blanks	1. Battery Electric Vehicles (BEVS)	2. Plug-In Hybrid Electric Vehicles (PHEVS)
	3. Hybrid Electric Vehicles (HEVS)	4. Fuel Cell Electric Vehicles (FCEVS)
	5. Neighbourhood Electric Vehicles (NEVS)	
B) Multiple Choice Questions	1. C	2. C
	3. A	4. C
	5. A	

Session 2: Components of Electric Vehicles

A) Fill in The Blanks	1. Lithium-Ion Battery	2 Vehicle Control Unit

B) Multiple Choice Questions	1. C	2. B
	3. C	4. A

Session 3: Differentiate Between Conventional Vehicles and Electric Vehicles

A) Fill in The Blanks	1. combustion chamber	2. Five
	3. 80%	4. Noise
B) Multiple Choice Questions	1. B	2. B
	3. A	4. A
	5. B	

Module 3: Electric and Electrical System of EVs

Session 1: Fundamentals of Electricity and Terminology

A) Fill in The Blanks	1. Voltage	2. Current
	3. Resistance	4. Capacitor
B) Multiple Choice Questions	1. C	2. A
	3. B	4. A
	5. A	

Session 2: Common Electrical and Electronics Symbols

A) Multiple Choice Questions	1. A	2. B
	3. B	4. A
	5. B	6. C

SESSION 3: Sensors Used in Electric Vehicles

A) Fill in The Blanks	1. Parking Assistance	2. Longevity
	3. Velocity	4. Range
	5. Electrical	
B) Multiple Choice Questions	1. C	2. C
	3. B	4. B
	5. A	

Module 4: Tools and Equipment Used in Workshop

Session 1: Hand Tools

A) Fill in The Blanks	1 Screwdriver	2. Spanner
	3. Pliers	4. File
B) Multiple Choice Questions	1. B	2. C
	3. A	4. A

Session 2: Hand Cutting Tools

A) Fill in The Blanks	1. Material.	2. Reduce

	3.150mm to 200mm.	4. Cleaning Teeth, Removing Pinning
B) Multiple Choice Questions	1. D 3. C	2. C 4. C

Session 3: Measuring Tools

A) Fill in The Blanks	1. Multimeter 3. Outside, Inside, Depth	2. 200 Ohms 4. Inner, Outer
B) Multiple Choice Questions	1. B 3. D 5. D	2. A 4. C

Session 4: Service Equipment

A) Fill in The Blanks	1. Non-Metal 3. Tire Wear	2. Battery Maintenance
B) Multiple Choice Questions	1. D 3. C	2. D

Session 5: Power Tools

A) Fill in The Blanks	1. Multimeter 3. Wheels	2. Pneumatic Guns 4. Pressure Differences
B) Multiple Choice Questions	1. B 3. A	2. A 4. C

Session 6: EVs Diagnostic Tools

A) Fill in The Blanks	1. On-Board Diagnostics 3. Battery testing 5. Tire Pressure Monitoring Systems	2. Sensors 4. Analyse, Monitor
B) Multiple Choice Questions	1. B 3. C	2. C 4. A

Module 5: Routine Service and Repair of An EVs

Session 1: Maintenance Schedule

A) Fill in The Blanks	1. Tire Life 3. Breakdown Maintenance	2. Wear or Malfunction
B) Multiple Choice Questions	1. B 3. D	2. D 4. A

Session 2: Job Card

A) Fill in The Blanks	1. Job Card 3. Warranty Card	2. Customer 4. Coverage
B) Multiple Choice Questions	1. A 3. D	2. D 4. C

Session 3: Standard Operating Procedure (SOP) For Receiving Vehicles

A) Fill in The Blanks	1. Standard Operating Procedure (SOP)	2. Documentation
	3. Vehicle Identification Number (VIN)	4. Records
B) Multiple Choice Questions	1. B	2. C
	3. C	4. B

Session 4: Invoicing Vehicle Delivery and Handling Complaints

A) Fill in The Blanks	1. Transaction	2. Professional
	3. Customers	
B) Multiple Choice Questions	1. B	2. B
	3. A	4. C

Session 5: Inspection and Testing of Electric Vehicles Components

A) Fill in The Blanks	1. Disconnected	2. Owner's Manual
	3. Performance	4. Failures
B) Multiple Choice Questions	1. B	2. A
	3. C	4. B

Session 6: Safety of The High-Voltage System

A) Fill in The Blanks	1. Power Back	2. Environmental
	3. High-Voltage System	4. Trained
B) Multiple Choice Questions	1. B	2. C
	3. C	4. A

Module 6: Health and Safety Equipment

Session 1: Safety Consideration for Electric Vehicles

A) Fill in The Blanks	1. Thermal	2. Electric Vehicle
	3. Electrical Fire	4. Wheel Chocks
B) Multiple Choice Questions	1. B	2. C
	3. D	4. D

Session 2: Personal Protective Equipment

A) Fill in The Blanks	1. Personal Protective Equipment	2. Head
	3. Cut-Resistant	4. Matting
B) Multiple Choice Questions	1. D	2. A
	3. C	4. B
	5. B	

Glossary

All-Electric Range (AER)	How far a vehicle can drive on electric charge alone. This is often used when talking about hybrid vehicles, which use electric power alongside other sources.
Alternating Current (AC)	The electrical standard homes are built on. It allows long runs of cable with less power loss.
Amp (A)	Amps (or amperes) are a measurement of electrical current. This measures how many electrons are passing through a point at a given time. One amp is equal to one coulomb (a unit of electrons) per second. Think of this as the water flow rate in your home plumbing. Amps are calculated by dividing power (wattage) by voltage.
Amp-hours (Ah)	A measurement of the total current a battery can emit over one hour. It is a common method of determining the total energy capacity of any given battery.
Anode	The side of the battery where electrons flow in.
Battery	Where an electric vehicle's power is stored. It's the EV equivalent of a gas tank. Our guide to how batteries work explains more of the intricacies and the history of how they came to be.
Battery cell	The smallest unit in an EV's overall battery pack. Thousands of cells are often required to store enough electricity for an EV.
Battery Electric Vehicle (BEV)	A car that runs purely on electric power, stored in an on-board battery that is charged from mains electricity (typically at a dedicated charge point).
Battery Heating System (BHS)	A system that ensures the battery pack remains at ideal operating temperatures. This is necessary in cooler temperatures, which adversely affect battery life and charging speed.
Battery Management System (BMS)	A system that ensures each cell is draining at roughly equal rates, and coordinates input and output so they all act as a single unit.
Battery module	A group of battery cells bundled together in an EV's overall battery pack.
Battery pack	The total structure of an EV's battery. It includes all modules and the cells that compose them, the enclosure, and structural features.
Capacitor	A module in an electrical circuit that retains power. It doesn't hold power for as long as a battery but is able to retain enough to

	accommodate temporary losses of power or to regulate spikes in power.
Cathode	The side of the battery where electrons flow out.
CHAdeMO	A kind of connector that charges up to 100kW. It is a four-pin, direct current standard often used in Asia.
Charge Point Installer (CPI)	Charge point installers sell and maintain charging points made by multiple manufacturers.
Charge Point Operator (CPO)	Charge point operators maintain a network of charging points, coordinate with site owners, manage installation and maintenance, and ensure operations with utilities go smoothly.
Combined Charging System (CCS)	Combined charging system is a kind of connector that charges up to 350kW. It includes DC charging pins often below a type 1 plug. Available in both Combo 1 and Combo 2 configurations for the US and Europe respectively. CCS is among the most common EV plugs.
Connector	The physical end of the cable at a charging point, which goes into your car. There are multiple connector types compatible with certain cars.
Direct Current (DC)	The electrical standard most modern electronics and EVs are built on. EVs typically need to convert AC power to DC in order to charge their batteries. Read more about direct current here.
Drive unit	The combination of an EV motor and its reducer.
Electric Power Control Unit (EPCU)	The electric power control unit combines the inverter, low voltage DC-DC converter, and vehicle control unit into a single unit overseeing major responsibilities in an EV's system management.
Electric Vehicle (EV)	A vehicle propelled by an electric motor. EV is a wide umbrella term that can encompass many different subtypes.
Electric Vehicle Service Provider (EVSP)	Electric vehicle service providers manage back-end software and communications for charging points.
Electric Vehicle Supply Equipment (EVSE)	Everything you need to charge your EV. This includes cables, connectors, and charging points. Primarily, EVSE includes safeguards to ensure you aren't overcharging and damaging your vehicle or endangering yourself.
Extended Range Electric Vehicle (EREV)	A vehicle that relies primarily on electric power, but also has a combustion engine as a backup for when the charge dies. Unlike a hybrid, the engine never drives the wheels directly.

Frunk	Since EVs don't have motors under the hood in the front, it's used for storage space. It's lovingly called the frunk, short for "front trunk".
Fuel Cell Electric Vehicle (FCEV)	A vehicle that relies on hydrogen fuel cells to charge the vehicle's battery.
Horsepower (hp)	A measurement of work being done. It is equal to the force in pounds multiplied by the distance in feet divided by time in minutes. It is a common means of measuring the power of a vehicle, though EVs often defer to kW.
Hybrid (HEV)	A vehicle that uses both an electric motor and an internal combustion engine to achieve better efficiency.
Inverter	An inverter converts a battery's direct current into an alternating current.
Kilowatt (kW)	One thousand watts.
Kilowatt-hours (kWh)	A measurement of the power of one kilowatt is maintained for one hour. It is a common method for determining the total power potential of any given battery.
Level 1 charging	The baseline charging level for EVs. It's what's available from a standard household outlet, providing a charge of up to 120V and between 8A and 20A. Level 1 charging typically takes a full 24 hours to top up an empty EV.
Level 2 charging	The charging level at most dedicated charging points. They charge EVs quite a bit more quickly with 240V output up to 80A. A full charge at a Level 2 point takes about 4 hours.
Level 3 charging	The fastest charging you'll find. These charging points use direct current to charge EV batteries quickly, often in a half hour. Tesla has a network of superchargers that take advantage of unique connectors to deliver level 3 charging rates. Level 3 charging goes up to 900V at over 100A.
Lithium-ion	The battery technology used on most EVs (and most electronics like your phone, for that matter). They offer very high energy density and the ability to be recharged many times.
Low voltage DC-DC Converter (LDC)	A component that reduces the voltage of an EV battery's power so it can be used by supplementary systems within the car, like the headlights.
Mild Hybrid Electric Vehicles (MHEV)	A vehicle that relies primarily on an internal combustion engine, with support available from a small electric motor. MHEVs are unable to operate on battery power alone.

Motor	The electrical heart of an EV. It converts electrical power into mechanical power by running a current through multiple circuits of wound copper wire shaped in a cylinder, which creates a rotating magnetic field. The rotation of the magnetic field moves a rotor housed within the cylinder. This rotor then rotates an axle and an EV's wheels.
Neighborhood Electric Vehicle (NEV)	A small, low-speed electric vehicle.
Off-peak charging	Charging your EV when electrical rates are at their lowest — typically at night.
Ohms (Ω)	A measurement of electrical resistance. Resistance determines how well a material conducts electricity. One of the reasons EVs charge more slowly in cold climates is because lower temperatures increase electrical resistance. Battery degradation can also increase resistance. A given wire's length, thickness, and material have a significant effect on resistance. Ohms are calculated by dividing voltage by current (amperage).
On-Board Charger (OBC)	On-board chargers convert alternating current to direct current in order to charge an EV's batteries. Fast-charging stations don't need to use an EV's OBC since they are already direct current.
Plug-In Hybrid Vehicle (PHEV)	A hybrid vehicle that includes a plug for charging its internal batteries, allowing it to run on electricity for longer than a conventional hybrid.
Range	How far an EV can drive on a single charge.
Range anxiety	A driver's worry that there isn't enough of a charge in an EV to complete their entire trip.
Range Extender (REx)	A small internal combustion engine used to recharge an EV's batteries.
Range Per Hour (RPH)	A measurement of charging time. Though it's possible to measure kW when charging, translating it into real performance will depend on vehicle design and weight. RPH takes those factors into account.
Reducer	The EV equivalent to a transmission converts the high torque of an electric motor to more rotations per minute.
Regenerative braking	A way for EVs to transfer the slowing momentum of the vehicle into additional charging for your battery.
Renewable energy	Electricity is generated by perpetual natural sources. Solar, hydroelectric, and wind power are all examples of renewable

	energy, in contrast to natural gas and oil, which exist in limited amounts and will eventually run out.
Resistor	A module in an electrical circuit that slows current. This can be used to split voltage between different routes, match voltage to meet certain tolerance levels, or even generate heat.
Revolutions Per Minute (RPM)	A measurement of how many times a shaft turns in a minute, particularly when transferring power from a motor to a crankshaft in a car. EVs enjoy much higher RPMs than internal combustion engines.
Single phase charging	A connector that has a single cable for power draw.
Site owner	The site owner is the entity that owns the property where a charging point is installed.
Solid-state battery	An emerging type of battery uses a solid electrolyte between the anode and cathode, rather than a liquid electrolyte. This allows solid-state batteries to be lighter, less explosive, and smaller. Several EV manufacturers have been pursuing solid-state batteries, but have yet to bring anything to market.
Supercapacitor	A much higher-capacity capacitor. Though it can retain more power than a lithium-ion battery and charge more quickly, it is less able to regulate output. Supercapacitors have been used in pilot projects with electric buses, so they can quickly charge at routine stops.
Three-phase charging	A connector that has three cables for power draw. These are typically required to benefit from level 3 charging.
Torque	The twisting force that rotates the tires of a vehicle. EVs typically have significantly higher torque than traditional cars, because electric motors produce it instantly from a dead stop, rather than needing to build speed like combustion engines.
Transistor	A module in an electrical circuit that modulates electrical power. This allows incoming electrical signals to be amplified, or switch from exiting onto one circuit from another.
Transmission	A set of gears that adjust the final power sent to the driveshaft, axles, and wheels. Cars switch between these gears in order to change the delivery of power without changing how fast the engine is running.
Type 1 plug	The most common EV connector charges up to 7kW. It is a five-pin, single-phase plug often used in the US. Also known as SAE-J1772 or a J plug.

Type 2 plug	A connector that charges up to 250kW. It is a seven-pin, triple-phase plug often used in Europe. It is sometimes called a Mennekes plug.
Vehicle Control Unit (VCU)	The processing centre of a vehicle, which coordinates power control, motor control, regenerative braking, power supply, and load management.
Volts (V)	A measurement of electrical force. It measures the amount of work needed to move an amp of energy between two points. Think of it like water pressure in your home plumbing. Voltage is calculated by dividing power (wattage) by current (amperage). You'll often see voltage ratings for charging stations. A higher voltage means a higher charging rate for your EV.
Watt-hours per kilogram (Wh/kg)	A measurement of the energy density of a battery, relative to weight. This is especially helpful in EVs, as heavier batteries will slow down the vehicle.
Watt-hours per liter (Wh/L)	A measurement of the energy density of a battery, relative to volume. With a high rating, a battery contains more energy proportional to its size.
Watts (W)	A measurement of electrical power. One watt is equal to one joule (a unit of work) per second. Wattage is calculated by multiplying voltage by current (amperage). Since watts consider the force and the flow rate of electricity, it is often the measure of the final electrical output for charging points.
Zero-Emission Vehicle (ZEV)	A vehicle that emits no pollutants from its operation.