

INTRODUCTION

Mechanical engineering is one of the traditional engineering fields, the engineering stream, integrates science and technology to create mechanical tools.

They design, build and test the tools used in manufacturing, agriculture, automobiles and others.

STREAMS IN MECHANICAL ENGINEERING:

Mechanical engineering is a broad discipline, and offers several **streams (specializations)** that focus on different aspects of engineering science, design, and application. Each stream has its own **significance** in industry, research, and societal development.

Here are the main streams in mechanical engineering and their significance:

1. Design Engineering

Focus: Conceptualization, analysis, and creation of machines, components, and systems.

Significance: Ensures reliability, efficiency, and safety of products; supports innovation in automotive, aerospace, robotics, and consumer goods.

2. Thermal Engineering

Focus: Heat transfer, thermodynamics, energy conversion, and power generation.

Significance: Forms the backbone of power plants, HVAC systems, renewable energy technologies, and internal combustion engines.

3. Manufacturing Engineering

Focus: Production processes like machining, welding, casting, CNC, additive manufacturing (3D printing).

Significance: Improves productivity, cost-effectiveness, and quality in industries such as automotive, aerospace, and consumer products.

4. Industrial & Production Engineering

Focus: Optimization of processes, plant layout, supply chain, quality control, lean manufacturing.

Significance: Enhances efficiency, reduces waste, and ensures smooth large-scale production in industries.

5. Mechatronics & Automation

Focus: Integration of mechanical systems with electronics, sensors, robotics, and control systems.

Significance: Crucial for Industry 4.0, smart manufacturing, robotics, and autonomous systems.

6. Automobile & Transportation Engineering

Focus: Design, development, and testing of vehicles, engines, and mobility solutions.

Significance: Addresses fuel efficiency, safety, and sustainable mobility (EVs, hybrids, autonomous vehicles).

7. Materials & Metallurgical Engineering

Focus: Study of metals, alloys, polymers, composites, and smart materials.

Significance: Enables development of lightweight, strong, and durable materials for aerospace, defence, and biomedical applications.

8. Robotics & Artificial Intelligence Applications

Focus: Intelligent automation, autonomous systems, human-machine interaction.

Significance: Transforms industries by enabling precision, adaptability, and advanced manufacturing systems.

9. Marine & Aerospace Engineering (Specialized Streams)

Focus: Design of ships, submarines, aircraft, spacecraft, and propulsion systems.

Significance: Expands exploration, defence, and global connectivity through advanced transport systems.

10. Energy & Environmental Engineering

Focus: Renewable energy systems, sustainable design, pollution control, energy efficiency.

Significance: Essential for addressing climate change, energy security, and sustainable industrial growth.

ROLE OF MECHANICAL ENGINEERS IN SOLVING THE REAL CASE PROBLEMS

1. Design & Innovation:

Develop new machines, devices, and systems tailored to real-world needs.

Ensure functionality, safety, efficiency, and cost-effectiveness.

Example: Designing ventilators during the COVID-19 pandemic to meet urgent healthcare demands with rapid prototyping and low-cost materials.

2. Energy & Sustainability:

Improve efficiency of energy systems to reduce costs and emissions.

Example: Engineers designed wind turbine blades with advanced composite materials to withstand high stresses while maximizing energy capture.

3. **Failure Analysis & Safety:**

Identify causes of mechanical failures and redesign systems for reliability.

Example: After bridge collapses, mechanical engineers conduct stress analysis and redesign joints or materials to prevent recurrence.

4. **Manufacturing & Automation:**

Optimize production lines to increase output while reducing waste.

Example: Engineers developed robotic welding systems in the automotive industry, improving precision, safety, and productivity.

5. **Healthcare & Biomechanics:**

Apply mechanical principles to medical devices and prosthetics.

Example: Design of artificial joints (hip/knee replacements) using biocompatible materials to restore mobility for millions worldwide.

6. **Transportation & Mobility:**

Enhance vehicle performance, safety, and environmental impact.

Example: Development of hybrid and electric vehicles, where mechanical engineers optimize battery cooling systems, lightweight materials, and aerodynamics.

7. **Disaster Management & Infrastructure:**

Provide engineering solutions in emergencies.

Example: After earthquakes, engineers design vibration isolation systems in buildings (base isolators, dampers) to minimize damage and save lives.

Role of Mechanical engineering in Industries:

1. Mechanical engineering is one of the basic branches of engineering & its fundamental principles are used in the design, development and construction of nearly all the physical devices & systems we see around us but not limited to automobiles, machines in all kind of factories, machineries used in building construction etc.
2. Mechanical engineers can work within a variety of industries such as aerospace, automotive, defence, marine, materials & Metals, Railways, etc.
3. They conceptualize design for any product to be manufactured. They also develop, test & manufacture the state-of- the art machinery.
4. The mechanical engineers are normally responsible for the design, specifications & the development of production process & equipment.
5. Typical examples of the technology that mechanical engineers deal include automobiles, aircrafts, turbines, robotics, etc.

Role of Mechanical engineering in Society:

1. Mechanical engineers are involved in designing, building and maintaining the engines, machines, structures that take modern life possible and comfortable.
2. They contribute to society by using their skills to improve the safety, security, efficiency and comfort of the systems and devices that we rely on every day.
3. Mechanical engineers are the peoples who research & carryout projects to help the society lives comfortably and effectively.
4. They develop machines in which most of them are very close to the lives of the people like gadgets from smartphones & tablets to big machines like cars & factory machines.
5. Eliminates excessive usage of resources by optimizing and improving efficiency.
6. Reduces human effort and makes work easy.

CAREERS IN MECHANICAL ENGINEERING:

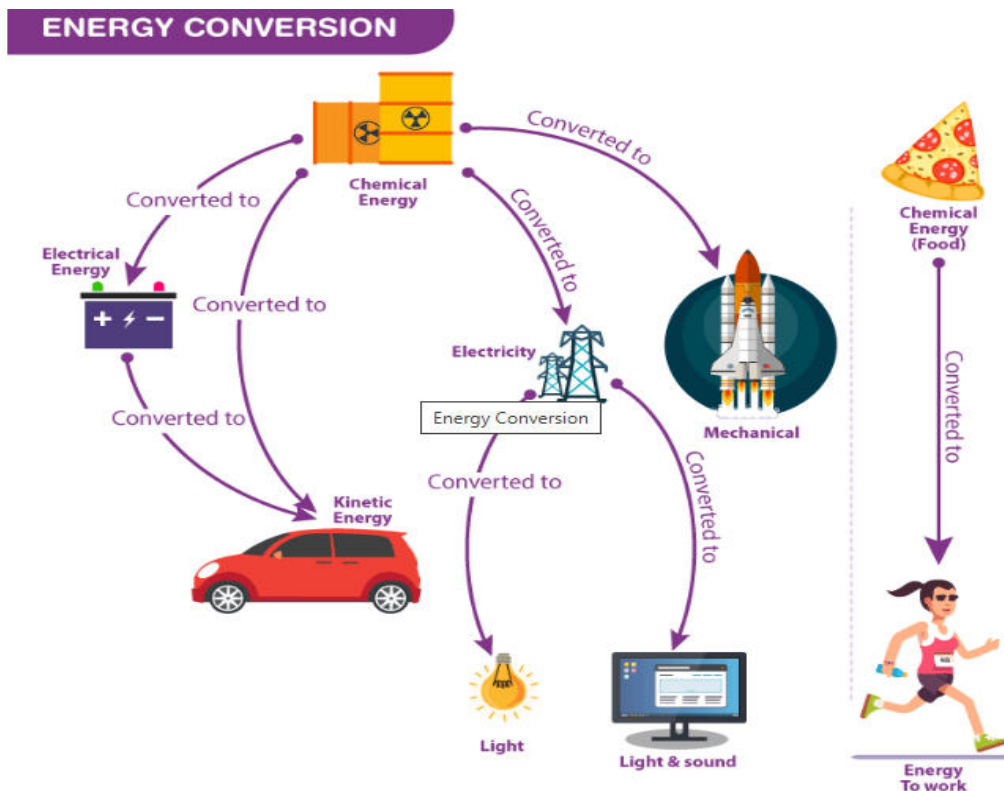
A career in mechanical engineering in India opens up a range of exciting job opportunities. Here are some promising career paths you can explore after mechanical engineering degree completion:

- 1. Automobile Engineer:** Designing and developing vehicles and their components.
- 2. HVAC Engineer:** Designing and maintaining heating, ventilation, and air conditioning systems.
- 3. Robotics Engineer:** Developing and managing robotic systems and automation processes.
- 4. Aerospace Engineer:** Working on aircraft and spacecraft design and development.
- 5. Energy Engineer:** Focusing on energy production, management, and sustainability.
- 6. Manufacturing Engineer:** Overseeing manufacturing processes and improving efficiency.
- 7. Maintenance Engineer:** Ensuring the upkeep and repair of machinery and equipment.
- 8. Design Engineer:** Creating and testing design models and prototypes.
- 9. Project Engineer:** Managing engineering projects, including planning and execution.
- 10. Research and Development Engineer:** Innovating and developing new technologies and products.
- 11. Quality Control Engineer:** Ensuring products meet quality standards and specifications.
- 12. Consulting Engineer:** Providing expert advice on engineering projects and systems.
- 13. Teaching/Academia:** Educating the next generation of engineers in academic institutions or through research.
- 14. Mechanical Engineer:** Design, analyse, and manage manufacturing of mechanical systems and devices.

Realization of some of the engineering solutions through principles of mechanical engineering

ENERGY CONVERSION:

- Energy conversion is the transformation of energy from one form to another, such as potential to kinetic energy, or from natural sources into usable power like mechanical or electrical energy, following the principle of conservation of energy.
- Whether the energy is transferred or transformed, the total amount of energy doesn't change, and this is known as the law of conservation of Energy.
- This field involves the design, analysis, and optimization of devices and systems that convert energy efficiently, with a focus on thermal systems, renewable energy technologies, and the integration of electrical and mechanical energy through electromechanical conversion.



ENGINEERING EXAMPLES OF ENERGY CONVERSION:

1) PELTON WHEEL TURBINE:

A Pelton turbine, also known as a Pelton wheel turbine, is an impulse turbine uniquely designed to convert the kinetic energy of water into mechanical energy.

The Pelton turbine operates efficiently in high-head, low-flow conditions typical of mountainous terrains.

The **Pelton wheel** is called an **impulse turbine** because:

- **Impulse action only** – The water jet from the nozzle strikes the buckets (spoons) of the Pelton wheel **at atmospheric pressure**. The pressure energy of water is completely converted into **kinetic energy (high-velocity jet)** before hitting the wheel.
- **No pressure change in runner** – Inside the runner (buckets), there is **only change in velocity direction**, not pressure. The jet glides along the curved bucket, changes direction, and transfers momentum (impulse) to the wheel.
- **Impulse principle** – The force (and thus torque) on the wheel is generated purely due to the **impulse of water jet** (Newton's 2nd law: change of momentum).

Reaction turbines (like Francis or Kaplan) work with both pressure energy and kinetic energy, and pressure changes occur as water flows through the runner. But in Pelton wheel, it works on the impulse of a high-speed jet, not pressure differences.

Figure 2: The key components of a Pelton turbine

The main parts of a Pelton turbine are –

(i) Nozzle and Flow Regulating Arrangement – Water striking the buckets (vanes) can be controlled by using a spear in the nozzle. A spear is a conical needle, which is operated either by hand wheel or automatically.

When spear is pushed forward into the nozzle, the amount of water striking the vanes is reduced and if the spear is pushed back, the amount of water striking the runner increases.

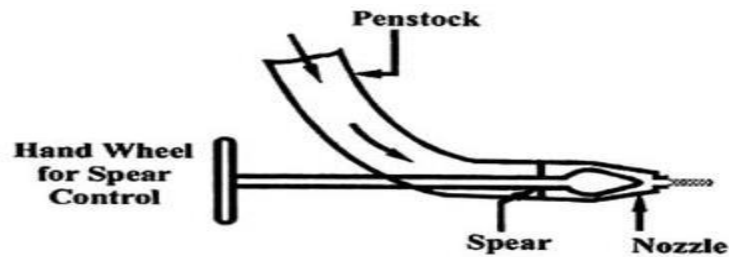


Fig: Nozzle with Regulating arrangement

(ii) Runner with Buckets or Vanes – The runner of a Pelton wheel consists of circular disc on which buckets are evenly spaced and fixed.

The shape of the buckets is of a double hemispherical cup or bowl. Each bucket is divided into two parts by the use of a dividing wall also known as splitter.

The buckets are so shaped that the jet of water gets deflected through 160° to 170° .



Fig: Pelton wheel bucket

(iii) Casing - A casing of a Pelton wheel is shown in Fig. The casing prevents the splashing of water and also directs the used water to the tail race. It is made of cast iron and does not perform any hydraulic function. It also acts as a safeguard against accidents.

(iv) Breaking Jets – When the nozzle is closed, i.e., the supply of hydraulic energy is closed even after that the wheel tends to move due to the inertia and thus wheel tends to revolve for a long time. To stop the runner in a short time, a small nozzle is provided which impinges a jet of water on the back of the vanes. This jet of water is called breaking jet.

Fig.: shows the layout of a Pelton turbine in which the water from the reservoir flows through the penstock at the outlet of which a nozzle is fitted. The nozzle increases the kinetic energy of the water flowing through the penstock. At the outlet of the nozzle, the water comes out in the form of a jet and strikes the buckets (vanes) of the runner. The jet of water strikes on the buckets with a high velocity and after flowing over the vanes, leaving with low velocity, thus imparting energy to the runner.

2) CENTRIFUGAL PUMP

Centrifugal pump is a hydraulic machine which converts mechanical energy into hydraulic energy (i.e. pressure energy) by the use of centrifugal force acting on the fluid. The flow of liquid takes place in radial outward direction which is reverse of the inward radial flow reaction turbine. It is used in different areas where fluid is needed to raise from low level to high level.

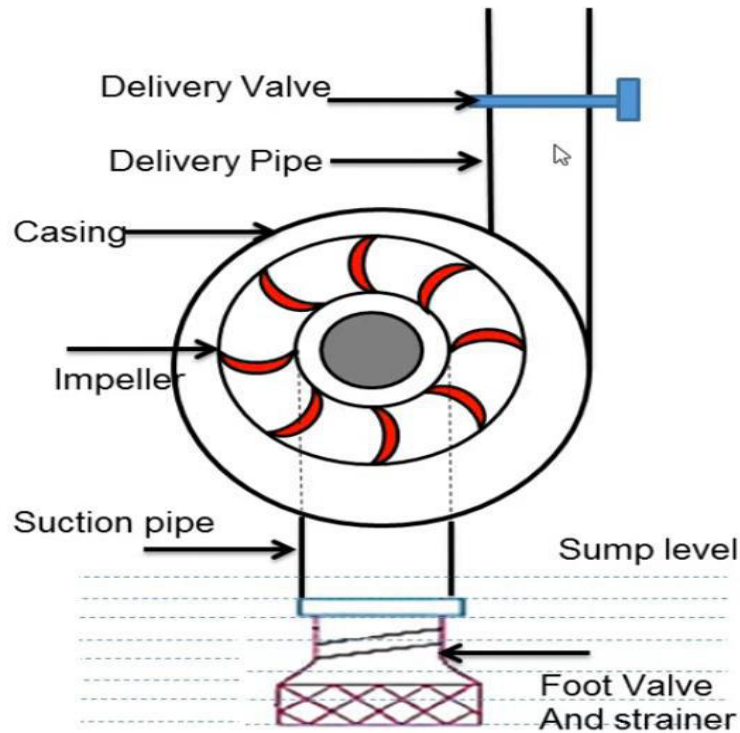


Fig: Components of Centrifugal pump

1. Impeller: It is the rotating part of the pump. The impeller is mounted on a shaft and the shaft of impeller is again connected with the shaft of an electric motor. It is rotated by the motor and consists of series of backward curved blades.

2. Casing: It is an air tight passage which surrounds the impeller. The design of the casing is done in such a way that it is capable of converting the kinetic energy of the water discharging from the outlet of the impeller into pressure energy before it leaves the casing and enters into the delivery pipe.

3. Suction Pipe with Foot Valve and Strainer: A pipe whose one end is connected with the inlet of the impeller and the other end is dipped into the sump of water is called suction pipe. The suction pipe consists of a foot valve and strainer at its lower end. The foot valve is a one-way valve that opens in the upward direction. The strainer is used to filter the unwanted particle present in the water to prevent the centrifugal pump from blockage.

4. Delivery Pipe: It is a pipe whose one end is connected to the outlet of the pump and other end is connected to the required height where water is to be delivered.

How Do Centrifugal Pumps Work?

- As the electric motor starts rotating, it also rotates the impeller.
- The rotation of the impeller creates suction at the suction pipe. Due to suction created the water from the sump starts coming to the casing through the eye of the impeller.
- From the eye of the impeller, due to the centrifugal force acting on the water, the water starts moving radially outward and towards the outer of casing.
- Since the impeller is rotating at high velocity it also rotates the water around it in the casing. The area of the casing increasing gradually in the direction of rotation, so the velocity of the water keeps on decreasing and the pressure increases, at the outlet of the pump, the pressure is maximum.
- Now form the outlet of the pump, the water goes to its desired location through delivery pipe.

STEERING SYSTEM

- The steering system provides the change in the direction of motion of a vehicle. This is achieved by converting the rotary motion imparted to the steering wheel by the driver into the angular turns of the front wheels.
- Rack-and-pinion steering is quickly becoming the most common type of steering on cars, small trucks and SUVs. It is actually a pretty simple mechanism. A rack-and-pinion gearset is enclosed in a metal tube, with each end of the rack protruding from the tube. A rod, called a tie rod, connects to each end of the rack.

The rack-and-pinion gear set does two things:

- It converts the rotational motion of the steering wheel into the linear motion needed to turn the wheels.
- It provides a gear reduction, making it easier to turn the wheels.

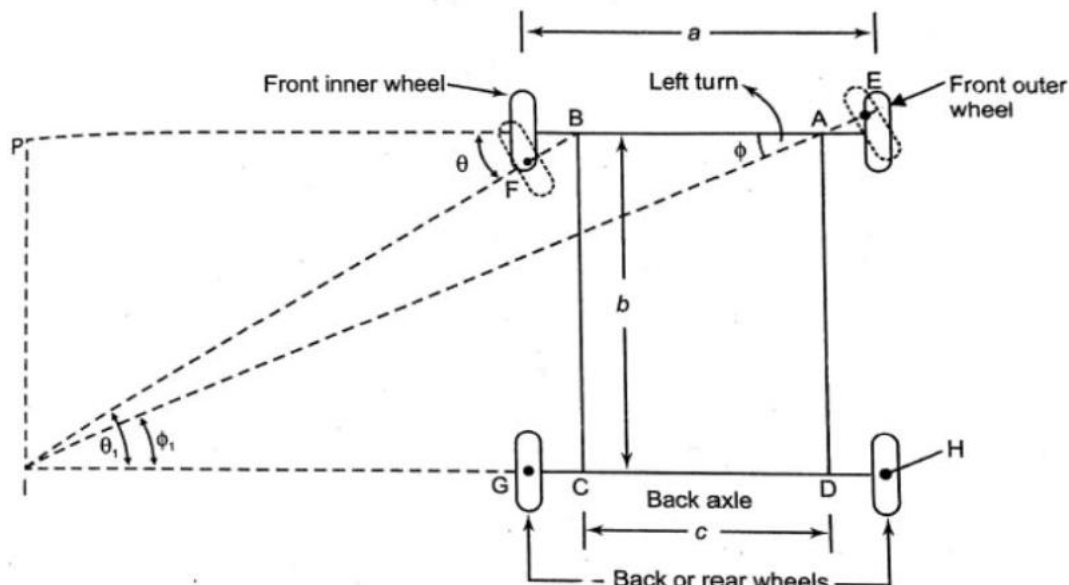
On most cars, it takes three to four complete revolutions of the steering wheel to make the wheels turn from lock to lock (from far left to far right).

The steering system should possess the following qualities:

- 1) It must be capable of keeping the wheels in true rolling motion at all times without rubbing or scuffing of tyres on roads.
- 2) It should have a certain degree of self centring action to keep the vehicle on straight path.
- 3) It must be easy to operate.
- 4) It should be light i.e. it should not require excessive effort to turn the steering.

Principle of correct steering:

- The steering gear mechanism is used for changing the direction of two or more wheel axles with reference to the chassis.
- So as to move the vehicle, usually, the two back wheels have a common axis, which is fixed in direction with reference to the chassis and steering is done by means of the front wheels.
- In automobiles, the front wheels are placed over the front axles, which are pivoted at the points A and B as shown in figure and these points are fixed to the chassis. the rear wheel is placed over the back axle.
- When the vehicle takes turn, the front wheels along with respective axles turn about the respected pivot points. The rear wheels remain straight and do not turn. Therefore, steering is done by means of front wheels only.



- In order to avoid skidding, the two front wheels must turn about the same instantaneous centre I, which lies on the axis of the back wheels.
- If the instantaneous centre of the two front wheels do not coincide with instantaneous centre of the rear wheels, the skidding on front or rear wheels will definitely take place, which will cause more wear and tear of the tyres.
- Thus, the condition of correct steering is that the four wheels must turn about the instantaneous centre.

Working of Steering System:

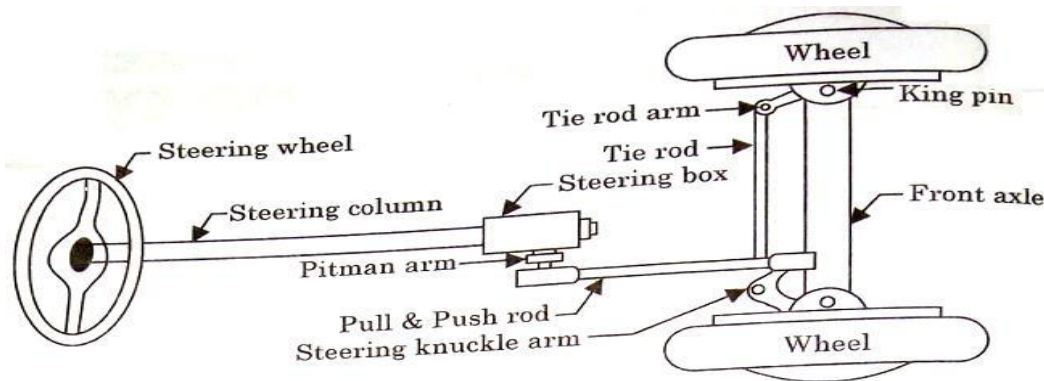


Fig: Steering system

The steering system consists of following major components as shown in figure.

- 1) **Steering wheel:** The steering wheel is the interface for driver input and is typically connected to the steering column.
- 2) **Steering column and shaft:** It connects the steering wheel to the gear mechanism and often has joints that handle misalignment between the steering wheel and the wheel.
- 3) **Steering gear box:** The gear mechanism converts the rotational motion of the steering wheel into the linear movement needed to turn the automotive steering wheels.
- 4) **Steering linkages (steering arm, drag link or tie rod):** They link the steering gear to the steering knuckles, and they function in maintaining wheel alignment and absorbing shocks during driving.
- 5) **Steering knuckle (or stub axle):** Attach the wheels to the suspension system and pivot when the steering input is applied, allowing the wheels to change direction.

WORKING:

- When the driver turns the Steering Wheel, the motion is transferred down the Steering Column.
- The rotation of the column spins the Pinion Gear where it meshes with the Steering Rack.
- The rotating pinion gear forces the straight steering rack to move linearly (side-to-side) across the car.
- The linear movement of the rack pushes or pulls the Tie Rods.
- The tie rods transfer this force to the Steering Knuckles, causing the front wheels to pivot and change the vehicle's direction.

Flow of Action

Driver's hand → Steering Wheel → Steering Column → Steering Gearbox → Linkages → Steering Knuckle → Front Wheels Turn

Why Do We Need Power Steering?

As we have already discussed above a power steering decreases the steering efforts which is the need of a 4-wheel automobile vehicle, so we need a power steering due to the following reasons

Quick Response- As the number of the vehicles on the road is increasing day by day and today almost 60% of families of the world have a 4 wheeler in their houses, with this increase in the number of vehicles the danger of accidents on road is also increased, so to avoid this danger and to take quick turns required by the road conditions a quick response steering system is required in a 4 wheel vehicle.

Steering Efforts – If we drive old cars like Maruti Suzuki 800, it is found that the steering wheel of the car feels very hard to rotate when the vehicle is going below 40 km/hr (above that the steering feels less hard) which is found to cause fatigue to the driver while going on a long ride. So a vehicle should be equipped with a power steering system so that the steering effort required to steer the front wheels can be reduced.

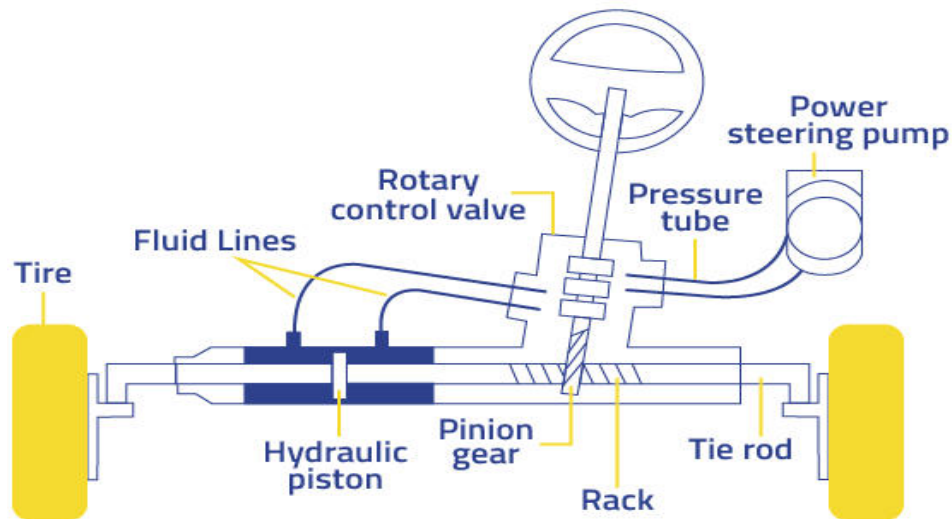
Bump Steer- As we know the bumps of the road is reduced by the suspension system but as the steering system is directly attached to the wheel's hub some amount of bumps force is also transferred to the steering system which in turn tries to steer the vehicle against the will of the driver due to which a vehicle can lose its stability, though the bump steer can be controlled mechanically by providing optimum scrub radius (angle between the centre line of the wheel and the king-pin inclination of the knuckle) but the power steering controls it in a more effective manner.

Return Ability- After taking a turn it is found that the steering returns automatically to its original position which in turn automatically straightens the moving vehicle. A vehicle equipped with a power steering system provides better return ability to the steering system.

POWER ASSISTED STEERING MECHANISM:

Most steering systems in modern cars are power-assisted. The dominant system is hydraulic power assisted steering (HPAS).

A pump powered by the car's engine forces hydraulic fluid to operate a piston located at the steering gears.

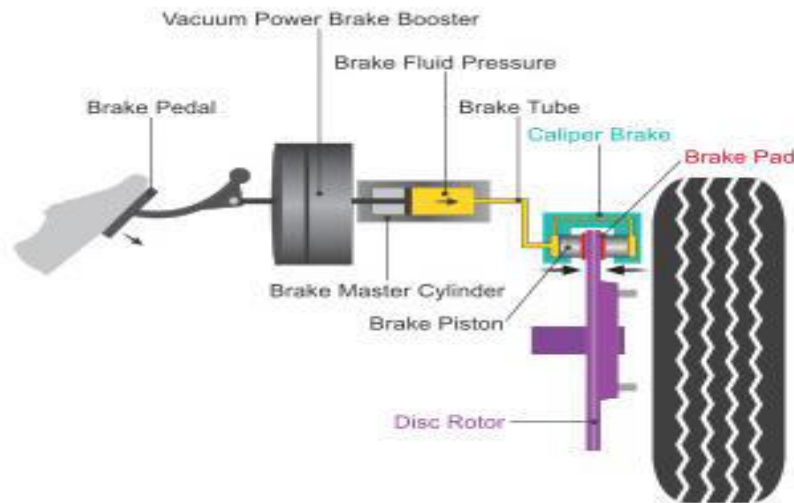


WORKING:

- When the driver provides input by rotating the steering wheel, the hydraulic pump driven by the engine starts pumping the highly compressed hydraulic fluid through lines.
- The hydraulic pressure produced by the pump enters the hydraulic cylinder which in turn applies pressure over the cylinder's piston.
- The piston which is under high pressure starts moving from one end to the another which in turn pushes the further fluid through lines, with this movement of piston the input force applied by the driver is multiplied several times.
- This high pressure fluid sent by the hydraulic cylinder then applies the pressure to the attached pinion through the coupling mechanism which in turn applies high force to the rack gear and the steering action in the front wheels takes place.

BRAKING SYSTEM:

The braking system is one of the most critical components of a car, ensuring the safety and control of the vehicle. It allows you as a driver to slow down or stop the car when necessary.



Components of a Car's Braking System

1. **Brake Pedal** – The brake pedal is the primary interface between you the driver and your car's braking system. When you apply pressure to the brake pedal, it initiates the braking process.
2. **Brake Master Cylinder** – The brake master cylinder converts the force applied to the brake pedal into hydraulic pressure. It contains a reservoir of brake fluid and is responsible for distributing the hydraulic pressure to the individual brakes.
3. **Brake Lines** – Brake lines are a network of metal or rubber tubes that carry brake fluid from the master cylinder to the individual brakes. These lines need to be sturdy and resistant to high pressure to ensure the efficient transfer of hydraulic force.
4. **Brake Calipers** – Brake calipers are found in disc brake systems and are responsible for clamping the brake pads onto the brake rotor. When the hydraulic pressure is applied, the calipers squeeze the pads against the rotor, creating friction and slowing down the rotation of the wheels.
5. **Brake Pads** – Brake pads are made of friction material (usually a composite of various materials) and are pressed against the brake rotor by the calipers. The friction generated between the brake pads and the rotor is what slows down the car.
6. **Brake Rotors** – Brake rotors, also known as brake discs, are metal discs attached to the wheels. When the brake pads press against the rotors, the resulting friction causes the wheels

to slow down or stop. Rotors are typically made of cast iron or composites, such as carbon-ceramic, for enhanced performance and heat dissipation.

7. **Drum Brakes** – Some older cars and certain vehicles still use drum brakes on the rear wheels. Drum brakes consist of a brake drum, brake shoes, and wheel cylinders. When the brake pedal is pressed, the wheel cylinders push the brake shoes against the inside of the brake drum, generating friction and slowing down the vehicle.
8. **Brake Fluid** – Brake fluid is a hydraulic fluid that transfers the force from the brake pedal to the brake calipers or wheel cylinders. It needs to have a high boiling point and excellent temperature stability to withstand the heat generated during braking.

Working of Hydraulic Brake System

- The hydraulic braking system plays a crucial role in executing brakes and operates on a straightforward principle. It consists of two main types of brakes - disc brake and drum brake, with their execution techniques differing.
- When pressure is applied to the brake pedal, the master cylinder's piston forces the brake fluid to increase its pressure, which is then transmitted through the pipes to the wheel cylinders in accordance with Pascal's law.
- The increased pressure pushes out two pistons in the wheel cylinders, which in turn push against the brake shoes.
- This action causes the brake shoes to make contact with the brake drum, generating friction that slows down and stops the vehicle.

Role of material selection in improving brake disc and pad performance

Properties Required for Brake Materials

Property	Importance
High Coefficient of Friction	Ensures effective braking force
High Thermal Conductivity	Dissipates heat quickly to avoid fade
Thermal Stability	Maintains performance at high temperatures
Wear Resistance	Extends lifespan of discs and pads
Low Noise and Vibration	Enhances comfort and safety
Oxidation and Corrosion Resistance	Improves durability in harsh conditions

Both disc and pad materials must:

- Provide high and stable friction over a range of temperatures.
- Resist wear and deformation.
- Have good thermal conductivity to dissipate heat.
- Maintain structural integrity under repeated braking cycles.
- Exhibit compatibility between pad and disc (to prevent noise, vibration, and uneven wear).

Improvements to conventional braking systems for better energy efficiency and reduced wear.

- Regenerative Braking Integration
- Use of Low-Friction and Wear-Resistant Materials
- Advanced Brake Cooling Techniques
- Anti-lock Braking System (ABS) Optimization
- Reduced Mass and Rotational Inertia
- Lubricated or Coated Contact Surfaces

By combining material improvements, advanced control systems, regenerative energy recovery, and optimized thermal management, conventional braking systems can be made more energy-efficient and longer-lasting, while maintaining or improving safety.

GEAR SYSTEM:

The gear system in a car is one of the most important parts of the transmission system.

It is the system that transmits power from the engine to the wheels and allows the vehicle to move at different speeds efficiently.

Purpose of the Gear System

- To **transmit power** from the engine to the wheels.
- To **change torque and speed** as needed:
 - **Low gears** → more torque, less speed (for starting or climbing).
 - **High gears** → less torque, more speed (for cruising).
- To **enable reverse motion**.
- To **disconnect the engine** from the wheels (via neutral or clutch)

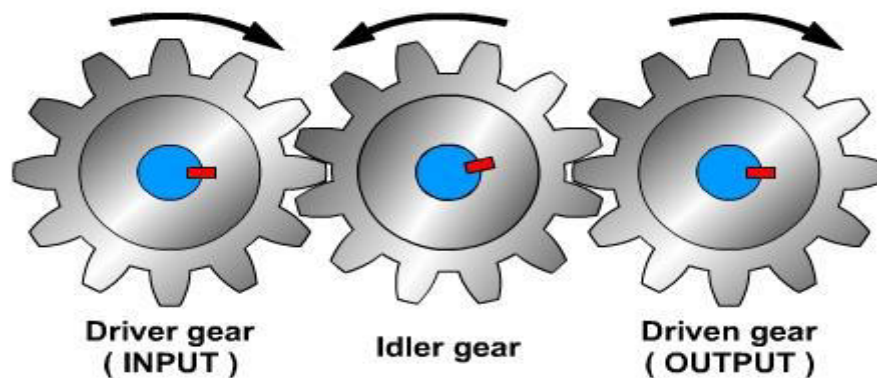
Basics of a car's gear system

When you press the accelerator, the engine produces rotational power. This power goes through an input shaft to the gearbox. Inside, different gears with specific gear ratios connect to the output shaft, which drives the wheels.

Lower gear: High torque, low speed – for climbing or carrying heavy loads.

Higher gear: Lower torque, high speed – for highways.

One reverse gear: Lets the car move backwards.



Basic Components

Clutch / Torque Converter – Connects and disconnects engine power.

Gearbox – Contains the gears and shifting mechanism.

Gear Selector – Allows choosing gears (manual or automatic).

Drive Shaft – Transmits power to the differential.

Differential – Splits power to wheels and allows cornering.

FLYING MACHINES:

A flying machine is any vehicle or device that is capable of lifting off the ground and moving through the air by generating lift, thrust, or both.

Classification:

1. Heavier-than-Air Machines (Aerodyne)

These flying machines generate lift due to motion through air, using wings, rotors, or jet thrust.

Types:

- **Aeroplanes (Airplanes):** Use fixed wings and engines to generate lift and thrust.
Example: Passenger planes, fighter jets.
- **Helicopters:** Use rotating blades (rotors) to lift vertically.
Example: Rescue helicopters, transport helicopters.
- **Gliders:** Have fixed wings but no engine; they glide using air currents.
- **Drones (UAVs):** Unmanned aerial vehicles controlled remotely or autonomously.

2. Lighter-than-Air Machines (Aerostat)

These flying machines **float** in the air because they are filled with a gas lighter than air (like helium or hydrogen).

Types:

- **Airships (Dirigibles):** Have engines and steering control; filled with helium or hydrogen.
Example: Goodyear Blimp.
- **Balloons:** Filled with hot air or gas; move with the wind and have limited control.
Example: Hot air balloons, weather balloons.



INTRODUCTION TO DRONE OR UAV

Any aircraft or flying machine operated without a human pilot such machines is called an unmanned aerial vehicle (UAV). It can be guided autonomously or remotely by a human operator using on-board computers and robots.

During surveillance or military operation, UAVs can be a part of an unmanned aircraft system (UAS), Drones are separately for air and water

Working Principle

At its core, the working principle of drone operations is based on the balance of forces: lift, weight, thrust, and drag. Drones achieve flight by generating lift through their propellers or rotors, which counteracts gravity. Thrust is generated when the propellers spin at high speeds, pushing air downwards and lifting the drone upwards. Simultaneously, the motors adjust the rotational speed of each propeller to control roll and pitch, allowing the drone to maneuver in three-dimensional space.

The flight controller - often called the "brain" of the drone - interprets input from sensors such as accelerometers, gyroscopes, magnetometers, and GPS modules. It then adjusts motor speeds to stabilize the drone and follow pilot commands or autonomous pre-planned missions.

The quadcopter system is assembled from some basic components. For greater clarity, each component is enumerated below:



Fig: Parts of a Drone

1. Drone frame or chassis

- The frame or chassis is the body of the drone and is the component that serves the function of holding all the parts together. Therefore, each of the parts of a drone are attached to it according to a configuration that allows the UAV to have an excellent aerodynamic performance.
- It functions as the structure of a drone that allows all the components to be assembled and is usually the one that defines the size of the drone.

2. Arms

- The arms of a drone are the components that support the motors and are attached to the frame or base structure of the drone.
- Long arms offer greater stability, while short arms allow for better manoeuvrability. In some cases, the arms are part of the drone's base structure or frame, so they are not counted as separate parts.

3. Drone propellers

- The motors do not have the capacity to lift the drone on their own, as they must be connected to propellers that are in charge of rotating to provide lift to the drone. Therefore, each motor has one or two propellers that together make up the powertrain.
- Most drones have a pair of standard propellers, which rotate counter-clockwise, and a pair of reverse propellers. This provides greater stability during flight.

4. Antenna

- The antenna is a crucial component for communication and navigation.
- It is used to transmit and receive signals between the drone and its controller or other systems.

5. Camera

- The camera is one of the most important parts of a drone when used for aerial photography or drone filming.
- Although not all drones have this element, it is one of the most common accessories, so the body of the drone usually has the necessary structure to install a camera on its base.

6. Battery

- The motors as well as the other electrical and electronic components of the drone need power to operate, which they get from a battery that is located in the frame.

- There are various types of batteries for drones, although the most common are Li-po batteries, which offer great performance and autonomy in flight.

7. Motors

- Another element of a drone that is of great importance is the motors. They are the fundamental parts that help keep the drone up and running.
- The motors of a drone are located at the ends of each of the arms of the frame and are responsible for generating the propulsive force for the drone to soar.

8. Gimbal

- This part of the drone is essential for stabilising the camera during drone flight.
- It is a complement that is placed between the frame and the camera, to prevent the vibrations of the motors from affecting the quality of the images captured with the drone.

9. Flight Controller Board

- One of the most important parts of a drone is the controller board (not to be confused with the identification plates or number plates of a drone) which acts as the “brain” of the UAV.
- This drone flight controller is responsible for receiving and recording all the information coming from the controller, the geolocation system, the sensors and other interconnected elements, while sending the necessary signals to control the drone’s movements during flight.

10. Sensors

Although not all drones have the same components, they usually have a number of sensors that are important for the drone’s performance. These include:

- **Speed sensor:** This allows the speed at which the drone is moving to be determined by interpreting the air pressure impacting the device.
- **Height and altitude sensors:** these sensors use pressure variation to detect how high the drone is flying in relation to the ground, and its position in relation to sea level. This data is of great importance in order to maintain the maximum altitude at which a drone can fly, in accordance with current EASA drone regulations.
- **Position sensors:** these allow the drone’s position to be known in real time, through connectivity with GPS or any other global positioning system.

REFRIGERATION

Definition of a Refrigeration:

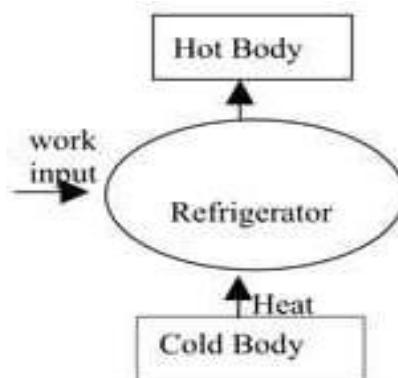
It can be defined as the process of reducing the temperature of the system below that of surroundings and maintains it at low temperature by continuously extracting heat from it.

Principle of Refrigeration:

The principle of refrigeration is based on second law of thermodynamics. It states that heat does not flow from a low temperature body to a high temperature body without the help of an external work.

In refrigeration process, since the heat has to be transferred from a low temperature body to a high temperature body some external work has to be done according to the second law of thermodynamics as shown. This external work is done by means of compressor, condenser, etc.

The machine which works under this principle and serves the purpose of refrigeration is called a Refrigerator.



BASIC DEFINITIONS:

1. **Refrigerator:** it is a machine used to extract heat from a body at low temperature and reject this heat to a body at high temperature. Thus it cools the body.
2. **Refrigerant:** The media which continuously extracts heat from the space in the refrigerator where Temperature is to be reduced and maintain below that of the surroundings by rejecting heat (to the surrounding) is called as Refrigerant. The commonly used Refrigerants are carbon di-oxide, Sulphur di-oxide, ammonia, freon-12 and Freon - 22.
3. **Unit of refrigeration:** The Unit of Refrigeration is expressed in Kilo Watt (KW) OR KJ/Sec
4. **Refrigeration Effect:** Refrigeration Effect is the rate at which Heat is extracted by the Refrigerator from the system. Higher capacity refrigerators mean higher will be the

refrigeration effect.

5. **Ton of refrigeration:** It is defined as the Quantity of heat to be extracted in order to form one Ton of ice in 24 hours given initial Temperature of water at 0°C. A Ton of Refrigeration for water = 210 KJ/Min OR 3.5 KW.
6. **Ice making capacity:** It is defined as the capacity of Refrigerating system to make Ice starting from water at room temperature. It is usually specified by Kg/hr.
7. **Coefficient of performance (COP):** Coefficient of performance is defined as the ratio of heat extracted from the system to the Work supplied.

$$\text{COP} = \frac{Q}{W} \text{ where } Q = \text{amount of heat supplied in KW,}$$
$$W = \text{Work done on the Refrigerator.}$$

TYPES OF REFRIGERANTS:

The commonly used refrigerants are as follows.

1. **Carbon die oxide:** It is a colorless, odorless, non-toxic, non-flammable. Needs a high operating pressure hence high compression is required. Not much used for domestic refrigerators
2. **Freon – 12 and 22:** It is a colorless, odorless, nontoxic, non-flammable. Widely used in Refrigerators and Air Conditioners.
3. **Sulphur dioxide:** Colorless and non-flammable. Extremely toxic and has pungent irritating odor.
4. **Ammonia:** It is highly toxic and flammable. It dissolves easily in Water. Used in vapour absorption refrigeration systems.

BASIC PROPERTIES OF REFRIGERANTS:

The followings are the basic Properties of Refrigerants.

1. Thermodynamic Properties:

- a) Refrigerant should have low freezing temperature
- b) Refrigerant should have high latent heat of vaporization
- c) Refrigerant should have high specific heat.

2. Safe Working Properties:

- a) Refrigerant should be non-toxic
- b) Refrigerant should be non-flammable
- c) Refrigerant should be non-corrosive and chemically stable

3. Physical Properties:

- a) Refrigerant should have Low Specific Volume of Vapour so that Compressor size can be minimized
- b) Refrigerant should have low viscosity

4. Other Properties:

- a) Refrigerant should have high COP
- b) It should be available easily and at low cost
- c) It should be odorless
- d) It should be easy for us to locate leakage.

VAPOUR COMPRESSION REFRIGRATION (VCR) SYSTEM:

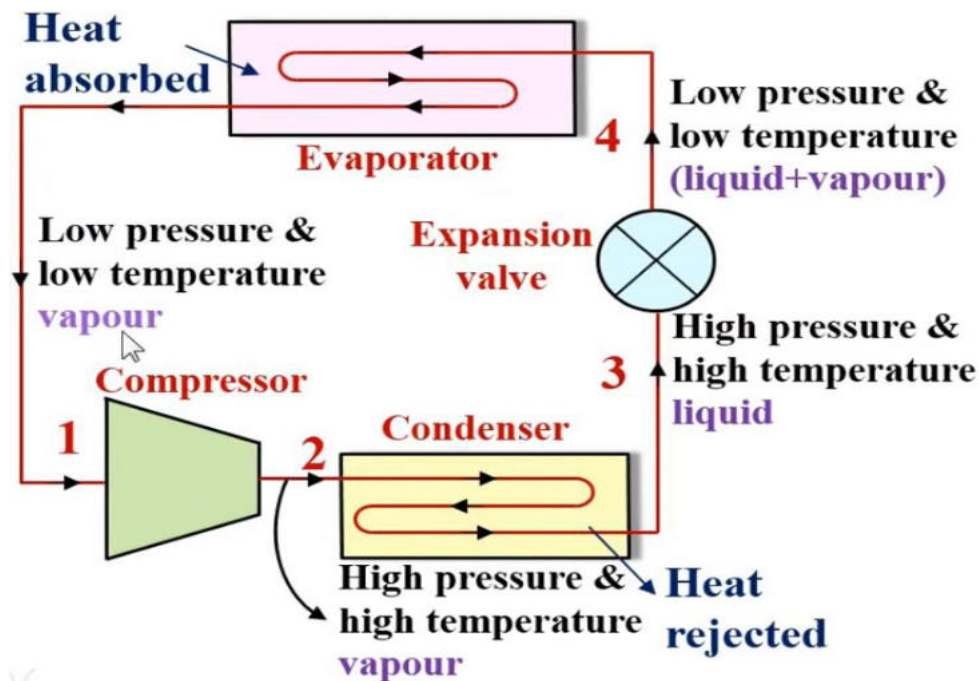


Fig: Schematic Diagram of VCR

1. **Refrigerant:** The working fluid that circulates through the system, absorbing and rejecting heat.
2. **Compressor:** Compresses the low-pressure refrigerant vapor from the evaporator into high-pressure, high-temperature vapor.
3. **Condenser:** Removes heat from the high-pressure refrigerant vapor, causing it to condense into a high-pressure liquid.
4. **Expansion Device (Valve):** Reduces the pressure of the liquid refrigerant from the condenser, causing partial vaporization and lowering its temperature.

5. **Evaporator:** Absorbs heat from the space or medium to be cooled, causing the low-pressure liquid refrigerant to evaporate into vapor.

The refrigerant used for VCR system is Freon- 12

Working:

- **1-2:** Vapour refrigerant at low pressure and low temperature is entered into the compressor where it is compressed to high pressure. So that temperature of vapour refrigerant increases.

Compressor pushes vapour refrigerant to the condenser.

- **2-3:** Condenser consists of pipe in which refrigerant gives its latent heat to the cooling medium.

Therefore, vapour refrigerant gets condensed in condenser. So that vapour refrigerant converts into liquid state.

- **3-4:** In an expansion valve/throttle valve, high pressure liquid refrigerant is expanded to low pressure and low temperature.

During throttling process enthalpy remains constant.

- **4-1:** an evaporator consists of pipe in which low pressure and low temperature liquid refrigerant is absorbed latent heat from space to be cooled.

Due to absorption of heat, liquid refrigerant is converted into saturated vapour.

Again this vapour enters into compressor and the cycle is repeated.

AIR CONDITIONING SYSTEM:

Air conditioning is the process by which

- AIR IS COOLED OR HEATED.
- CLEANED OR FILTERED.
- CIRCULATED OR RECIRCULATED.
- CONTROL THE QUALITY & QUANTITY

This means by air conditioning system the temperature, humidity & volume of air can be controlled at any time in any situation.

APPLICATIONS OF AIR CONDITIONING:

Air conditioning provides comfort for human beings and also a controlled environment for industrial activities. Hence, applications of air conditioning can be broadly divided into **comfort** and **process applications**.

Comfort applications: aim to provide an indoor environment that remains relatively constant in a range (Preferred for humans) despite changes in external weather conditions or in internal heat loads. Applications include:

- In residential buildings- single house and apartments
- Institutional buildings-offices, hospitals, large complex buildings, etc
- Commercial buildings-shopping centers, malls, etc
- Transportation-in aircrafts, automobiles, ships, etc

Process Applications: aim to provide a suitable environment for a process being carried out, regardless of internal heat loads and external weather conditions. Applications include:

- Hospitals- in operation theatres (to reduce the infection risk, to limit patient dehydration, etc)
- Clean rooms- for production of integrated circuits, pharmaceuticals and the like in which very high cleanliness and control of temperature and humidity are required.
- For breeding laboratory animals
- Textile factories
- Nuclear facilities
- Food cooking and processing areas
- Data processing centers.

Working of AC:

It works like a pump, an air conditioner draws heat from a space and releases it outside. It consists of a heat exchanger coil, compressor, and a mechanism that uses refrigerant gas in the operation. There is an absorption of heat during the transition from a liquid to a gas, a basic concept of physics that underlies the operation of air conditioning equipment. Practically, AC moves heat from a room's inside to its outdoor.

The refrigerant initiates as a low pressure, low temperature liquid in the evaporator coil of the house. Here, the heat from the room air is absorbed. In the meantime, heat absorption causes the refrigerant to change from a liquid to a low-pressure gas. The unit outside the home receives this gas after that.

Here, a compressor is utilized to raise the temperature and pressure of this gas refrigerant.

It is then moved to the condensation coil, which discharges the heat that was previously trapped inside your house into the atmosphere. A fan pushes air across the condenser for cooling and turning the refrigerant into a high-pressure liquid.

The cycle is then continued by reintroducing the refrigerant through the expansion valve into the house.

As a result, the heat (hot air) within your house is moved outside while promoting cooling.

COMPARISON BETWEEN REFRIGERATION AND AC

SL.No	Refrigeration	Air conditioning
1	Always cools to lower temperature	Cools in summer and heats in winter
2	The main purpose is to preserve perishable items	Main purpose is to provide human comfort and for industrial use
3	No humidifiers , de- humidifiers and driers are required	Humidifiers , de- humidifiers and driers are required
4	Units are located inside the room	Units are located Outside the room or on window
5	No fans are required	Fans are required for circulation
6	Doesn't have any control on dust or humidity	Control dust, humidity of air that is circulated