SME Unit VI – Mechanisms & Appliances

Contents : Part 1

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1. Introduction to Mechanisms :

Kinematics : The branch of physics that deals with the characteristics of motion without regard for the effects of forces or mass.

Kinematic Link : Each resistant body in a machine which moves relative to another resistant body is called Kinematic link or element. A resistant body is which do not go under deformation while transmitting the force. Kinematic links can be divided into three types :

- **Rigid link & Resistant link** : If there is absolutely no deformation in the link while transmitting the motion, is called Rigid Link which is ideal and does not exit. Hence, A Resistant body /link is defined which has negligible deformation during its motion. e.g All machine parts
- **Flexible link** : In this type of link, there is partial deformation while transmitting the motion. Belt drive is an example of flexible link.
- **Fluid link** : In this type of link, the motion is transmitted with the help of fluid pressure. Hydraulic brake is an example of fluid link.

Kinematic Pair : When the two Kinematic links are joined to have relative motion between them is known as Kinematic pair. The Kinematic pairs are classified as follows :

1. According to the Nature of Contact :

- **Higher pair** : When the two links have surface contact between them.
- **Lower pair** : When the two links have line or point contact between them.

2. According to Nature of Relative Motion :

- **Sliding Pair** : When one link slides relative to another link
- **Turning Pair** : When one link turns or revolve relative to another link
- **Rolling Pair** : When one link rolls over the other link (either point or line contact) – Ball or Roller bearings.
- **Screw Pair** : If pair have turning as well as linear motion between them- nut & bolt
- **Spherical Pair** : When a spherical link turns inside a fixed link, it is known as spherical pair.

3. According to Nature of Constraint :

- **Self closed Pair** : When the two links are joined together mechanically
- **Unclosed Pair** : When the two links are connected either due to gravity or by some external forces. E.g. Cam & roller

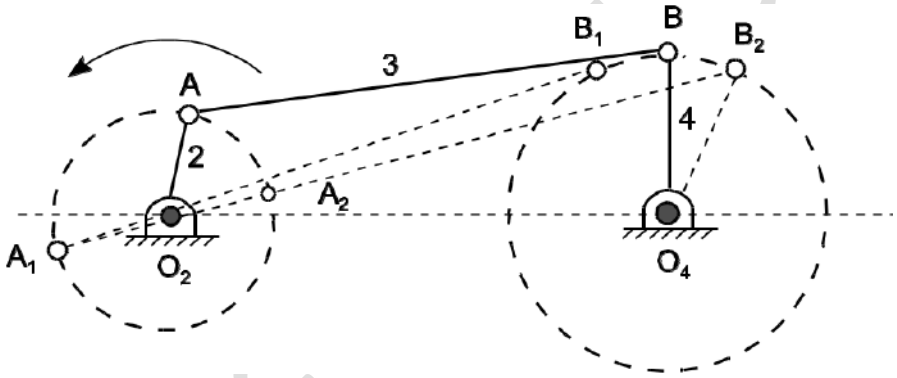
Difference between Machine and Mechanism :

SNo.	Machine	Mechanism
1	**If the system is used with the objective of transforming mechanical energy, then it is called a machine.**	**If the objective is to transfer or transform motion without considering forces involved, the system is said to be a mechanism.**
2	**Every machine has to transmit motion because mechanical work (force X displacement) is associated with the motion, and thus makes use of mechanisms.**	**It is concerned with transfer of motion only.**
3	**A machine can use one or more than one mechanism to perform the desired function, e.g. sewing machine has several mechanisms.**	**A mechanism is a single system to transfer or transform motion.**
4	**Machine is created with one or many mechanisms and giving power as input to get desired mechanical work as an output.**	**Mechanism is created by fixing one link of a Kinematic Chain. Fixing different links one at a time will create different mechanisms from the same chain, called Inversions.**

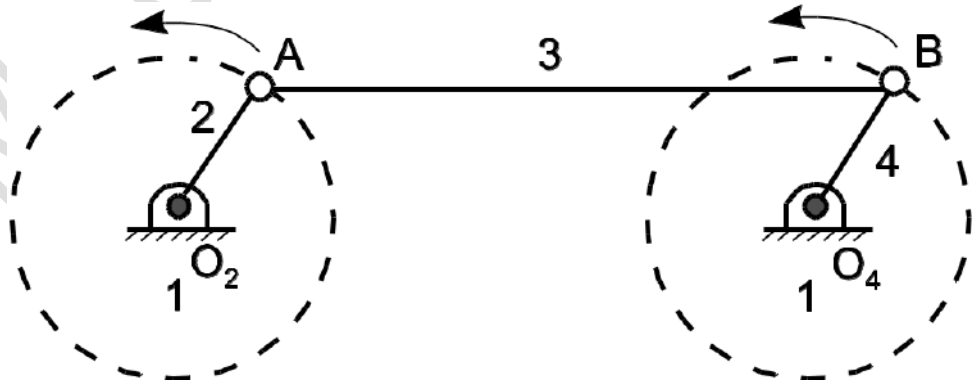
Four Bar kinematic Chain

- A four-bar linkage, also called a four-bar, is the simplest movable closed chain linkage. It consists of four bodies, called bars or links, connected in a loop by four pin or turning joints.
- Generally, the joints are configured so the links move in parallel planes, and the assembly is called a planar four-bar linkage.
- **Four Bar Mechanism** is created when any one link of Kinematic chain is fixed (no-movable). As there are four links, by fixing each link at a time will create four different mechanisms. This variety of mechanisms crated from the same kinematic chain are called **Inversions**.
- Crank is a link which has rotary or full circular motion. Lever or Rocker is link having Oscillating motion.

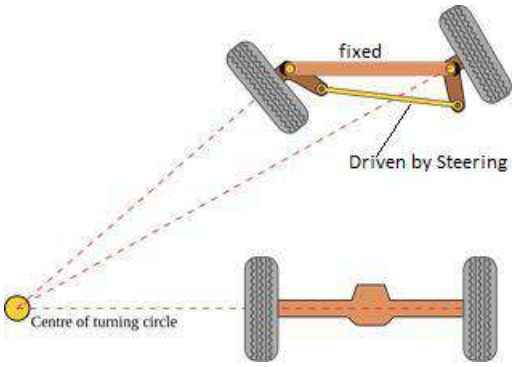
Inversions of Four Bar Mechanism (all 4 joints are pin joints)



1. Double-crank Mechanism or coupled Locomotive Wheels
: (Link 1 is fixed. link 2 & 4 are cranks.)



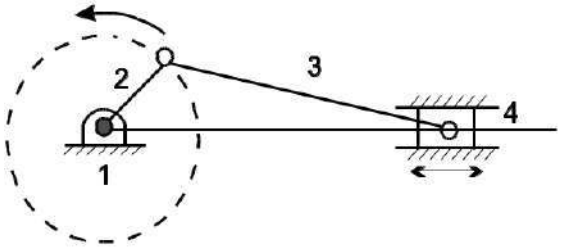
2. Double -Lever Mechanism or Ackermann Steering Gear Mechanism :



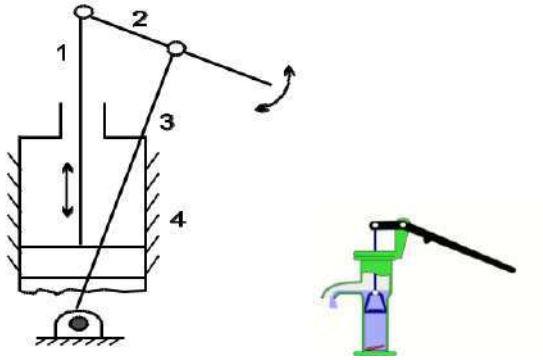
In this mechanism, fixed link is chassis of vehicle. Opposite link is driven by steering wheel- rack & pinion or Worm & worm wheel or Ball screw -gear arrangement. It can be moved manually or by Power (electric or hydraulic) called Power Steering.

Inversions of Single Slider and Crank Mechanism

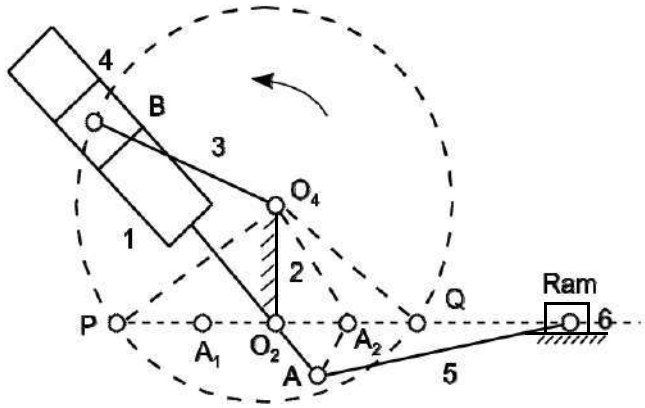
Reciprocating Engine (Link 1 is fixed)



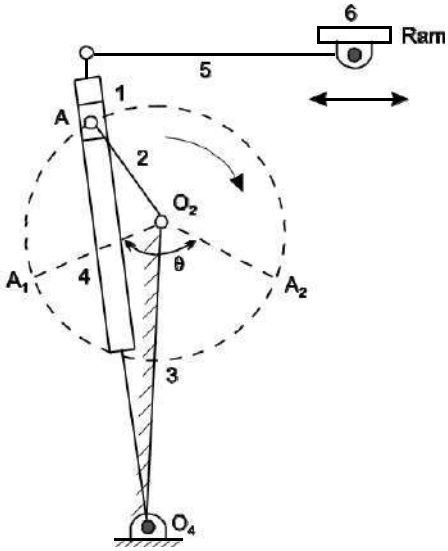
Hand Pump (Link 4 is fixed)



Whitworth Quick Return Mechanism (Link 2 fixed)



Crank-Slotted Lever Mechanism (Link 3 fixed)This is also a quick return mechanism



2. Pump

- These are hydraulic machines which convert mechanical energy into hydraulic energy. It is immaterial, whether that energy is utilized for lifting purposes or for raising the pressure. Pumps are driven by some prime mover which can be an I.C. engine, steam engine or an electric motor.

- In most of the cases pump is used for raising fluids from a lower to a higher level. This is achieved by creating a low pressure at the inlet or suction end and high pressure at the delivery end or outlet of the pump.

The pumps are classified as follows :

1. Reciprocating pumps (positive discharge type)
2. Centrifugal pumps (non-positive or rotary type)

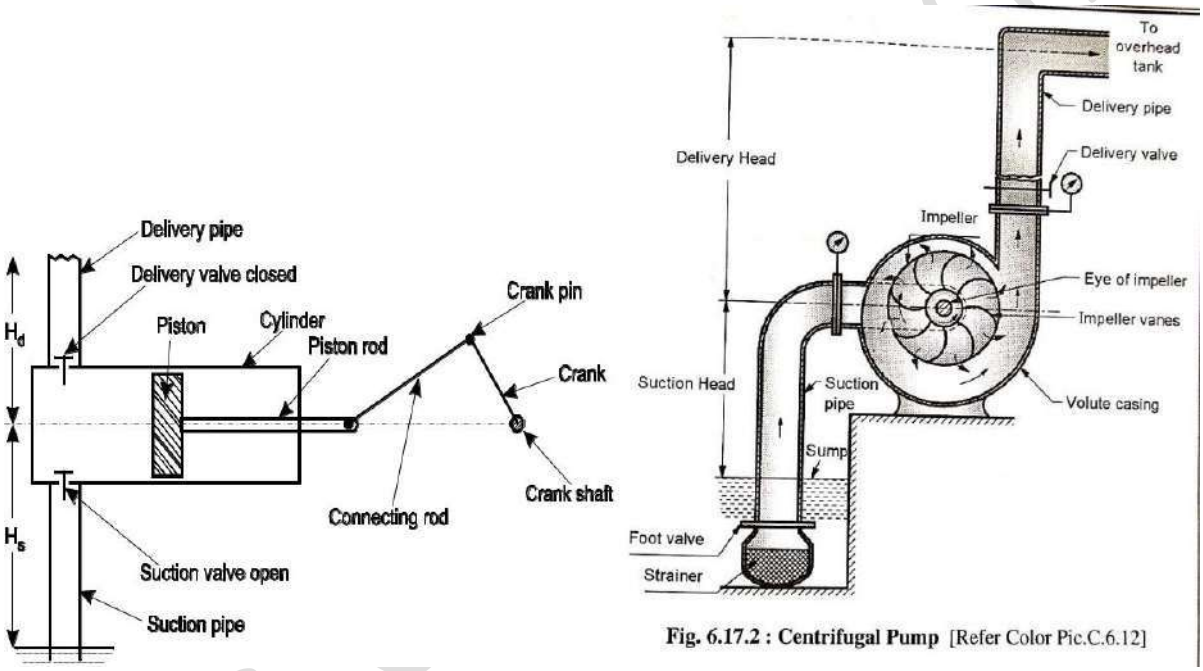


Fig. 6.17.2 : Centrifugal Pump [Refer Color Pic.C.6.12]

A Pump is a device that moves fluids- liquids/gases/slurries by mechanical action. It does not generate pressure. It produces the flow necessary for the development of pressure which is a function of resistance to fluid flow.

Working of Centrifugal Pump : Impeller is rotated by electric motor. Rotation of impeller inside a casing full of liquid imparts centrifugal head to liquid. It creates a vacuum at the eye of impeller and causes liquid to rise into suction pipe from sump continuously.

The rotary action of impeller imparts centrifugal head to liquid in the casing and it moves radially outwards with high velocity. Shape of casing is volute which gives increasing space to moving Liquid due to which velocity head is converted into pressure head. Hence it supports the vertical water column in outlet pipe and gives continuous discharge.

Centrifugal pump being non positive & continuous discharge type, its electric motor will not burn in case outlet pipe is blocked as churning takes place inside the casing.

Application of Centrifugal pump : Water pump for overhead tanks, pumps in water filters, water pumps in Power Plants, Pumps in hydraulic circuits, etc.

Power consumed by the Pump P = mgH = ρ.Q.g.H

Where, m = mass flow rate of liquid (kg/sec); Q = Volume flow rate of liquid (m^3 / sec);

P = Density of liquid (Kg/ m^3); H = Height through which liquid is lifted (Suction plus Discharge head) in meter.

Typical Specifications of a Centrifugal Pump :

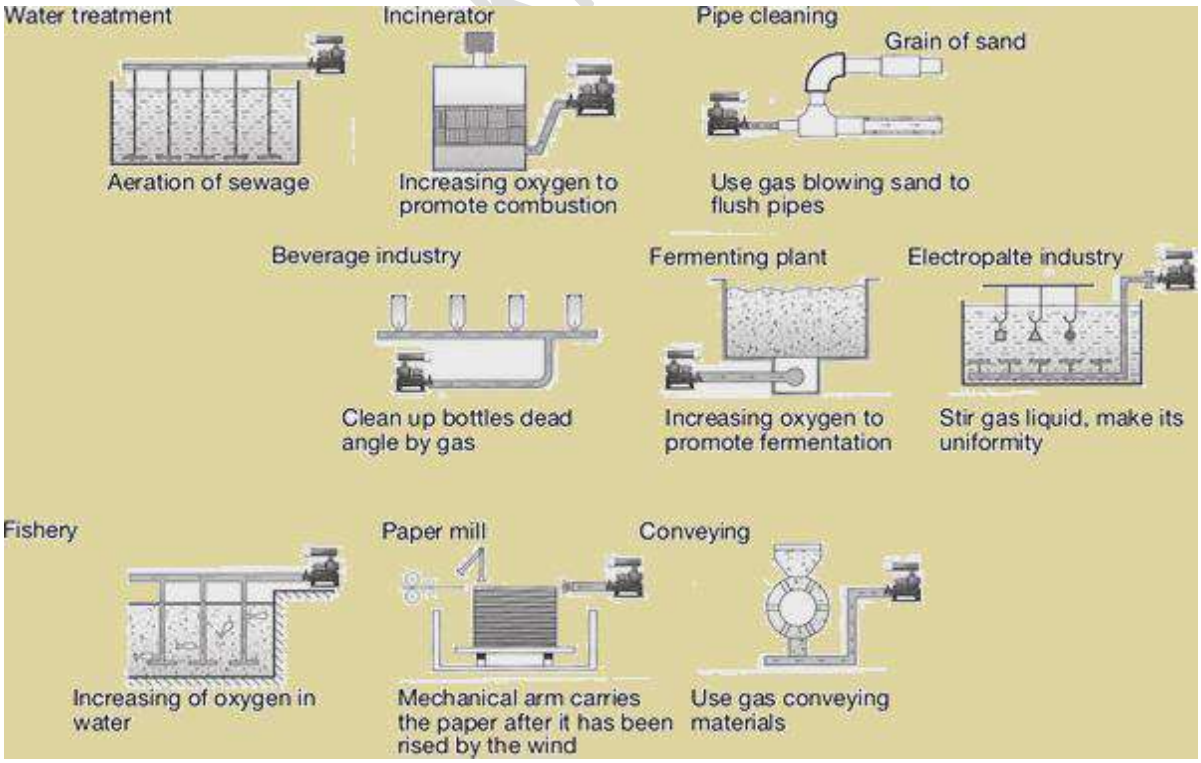
Power = 5 HP	Speed = 3000 RPM	Phase = 3	Voltage = 440 V
Head = 20 m	Discharge = 8.5 LPS (litres per second)	Outlet Pipe = 50 mm	Inlet Pipe = 65 mm

3. Blower

An **air blower** is a machine used for generating flow of **air** at substantial pressure. In Centrifugal **Blower** - **Air** enters axially and leaves the blade radial direction. The are used in air/gas circuit either to create Suction (Vacuum cleaner) or Blower (+ ve pressure).

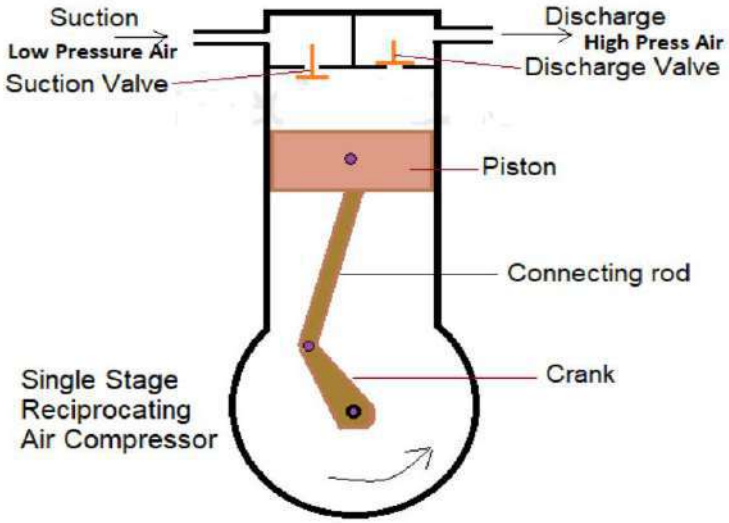
They are mainly used for flow of air/gas required for exhausting, aspirating, cooling, ventilating, conveying etc. Blower is also commonly known as Centrifugal Fans in industry.

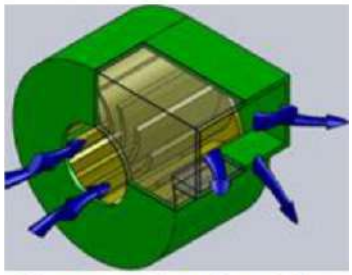
A **fan** is an electrical device, while a **blower** is a mechanical device. **Fans** have blades that help to creates a continuous airflow and circulate the air around in every direction, whereas a **blower** has impellers that channel the air in a specific direction towards a particular location.



Blowers are classified as : 1) Centrifugal Blowers: Gear driven impeller that accelerates air, but air flow drops if system pressure rises. It can be sigle or multi stage models & operates at 0.35 -0.7 kg/sq.cm pressure.

2)Positive Displacement Blowers: rotors trap air and push it through housing, supply constant volume of air regardless of system pressure. Suited for applications prone to clogging.





Blower or Centrifugal Fan

4. Air Compressor : An air compressor is a device which compresses the atmospheric air to a higher pressure at the expense of external work supplied either by an electric motor or by I.C. Engine. The compressed air at higher pressure is delivered to a vessel called Receiver for storage.

Working of single stage reciprocating compressor :

1. **Suction Stroke** : Suction valve is open and Discharge valve is closed. Piston moves downwards creating suction in the cylinder. Atmospheric air is sucked in till piston reaches at the end of stroke.
2. **Compression and Delivery Stroke** : Suction valve is closed. Air inside the cylinder is compressed by piston moving upwards. When the pressure inside cylinder reaches above the pressure on delivery side (i.e. Receiver pressure) ; then the delivery valve opens and the compressed air from the cylinder is discharged to the receiver.

Application of Compressed Air :

- To operate pneumatic tools in industry
- For Spray Painting
- For conveying bulk materials like Sand, Cement, concrete in pipeline
- For driving mining machinery where fire risks are high
- In refrigeration & Air Conditioning industry

5. Springs : A spring is a elastic or resilient body, whose function is to deflect or deform when load is applied and recover its original shape when load is removed.

Applications of Springs:

1. To apply force e.g. springs in clutches, brakes, valves, etc.

2. To measure force e.g . Spring

3. To store an energy e.g. springs in clocks, toys, switches, etc

4. To absorb shocks & vibrations e.g. springs in vehicle suspension systems.

Types of Springs : 1) Helical compression and Tension Springs; 2) Conical and Volute springs; 3) Torsion Springs; 4) Disc or Belleville Springs; 5) Leaf or Laminated Springs; 6) Spiral Springs

6. Gear Drive

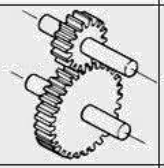
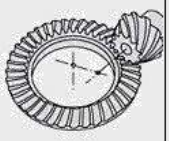
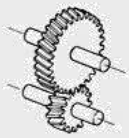
A gear is a kind of machine element in which teeth are cut around cylindrical or cone shaped surfaces with equal spacing. By meshing a pair of these elements, they are used to transmit rotations and forces from the driving shaft to the driven shaft.

Gears pair/drive reduces the output speed so that **we** get maximum torque to start wheel rolling & also we can change the direction of rotation of output shaft.

There are three major categories of gears in accordance with the orientation of their axes

- Parallel Axes / Spur **Gear**, Helical **Gear**, **Gear** Rack, Internal **Gear**.
- Intersecting Axes / Miter **Gear**, Straight Bevel **Gear**, Spiral Bevel **Gear**.
- Nonparallel, Nonintersecting Axes / Screw **Gear**, Worm, Worm **Gear** (Worm Wheel)

- Rack & Pinion (Straight gear) used to convert rotatary motion to linear & vice-versa.

Type	Spur	Bevel		Worm	Hypoid	Helical
		Straight Bevel	Spiral Bevel			
						
Shaft Arrangement	Parallel shaft	Intersecting shaft	Intersecting shaft	Non intersecting, non parallel shaft	Non intersecting, non parallel shaft	Parallel shaft
Meshing	Same pitch & pressure angle	same pitch, pressure angle & face width	same pitch, pressure angle & face width	same thread, pitch & pressure angle	same pitch, pressure angle & face width	Same pitch, pressure angle & helix angle
Gear Ratio	1:1 to 6:1	3:2 to 5:1	3:2 to 4:1	5:1 to 75:1	10:1 to 200:1	3:2 to 10:1
Efficiency	94-98%	93-97%	95-99%	50-90%	80-95%	94-98%
Features	Most common & cost-effective type of gear	Durable & ideal for high load applications	Highly durable & can handle high load than straight bevel	Can be used for special occupations	Durable & ideal for high load applications and transmit high torque	Higher strength and durable than spur gears
Noise and Vibration	Noisy	Less than spur gear	Less than straight Bevel	Quiet and Smooth	Quiet operation than spiral bevel	Less than spur gears
Application	Conveyors, Constant	Printing press, Differential gear	Tractors, final reduction gearing	Anti Reversing, Indexing devices	Large trucks	Automobile transmission

Advantages and Disadvantages of Gear Drives over Other Drives

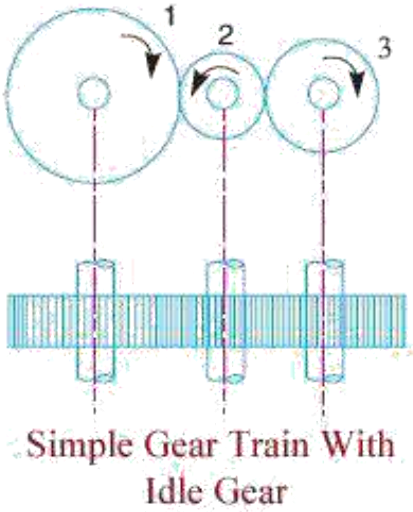
Advantages :

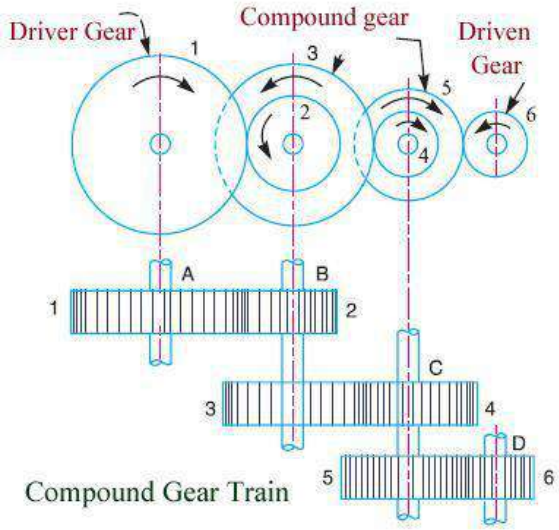
- It provides **constant** velocity ratio as it is **positive drive**.
- It transmits **more** power than other systems.
- Its transmission efficiency is high and long working life.
- It transmits power with very low velocity due to high reduction ratios.
- It requires minimum space as it is **compact** in size.

Disadvantages :

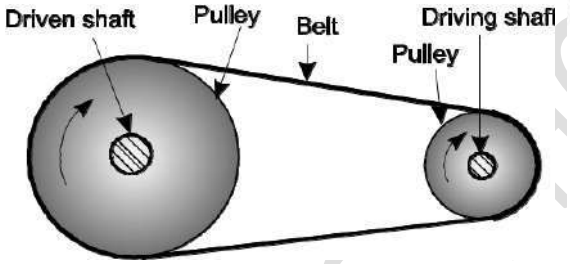
- Cannot be used for long centre distance
- Cannot absorb shocks, need precise alignment of shafts
- This system requires **lubrication** for smooth working.
- Its manufacturing **cost** is considerably high and manufacturing is also complicated

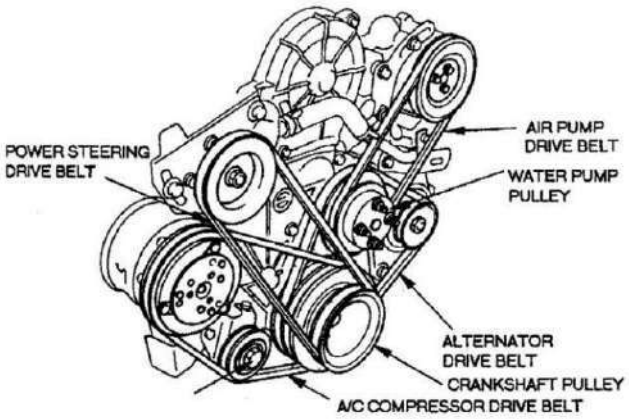
Gear Train is any combination of gears used for transmitting motion and power from one shaft to another shaft. It provides Gear Ratio to reduce or increase the speed of output shaft as well as can change the direction of rotation with or without using Idler Gears.





6. Belt-Pulley Drives :

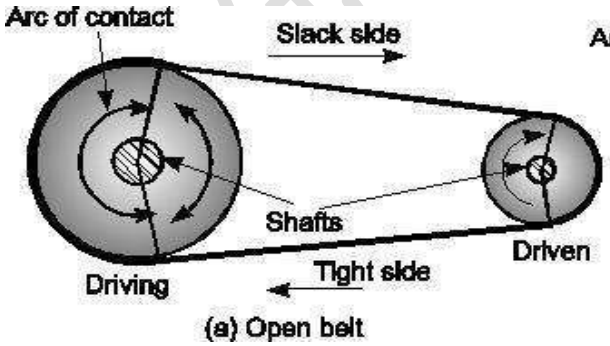


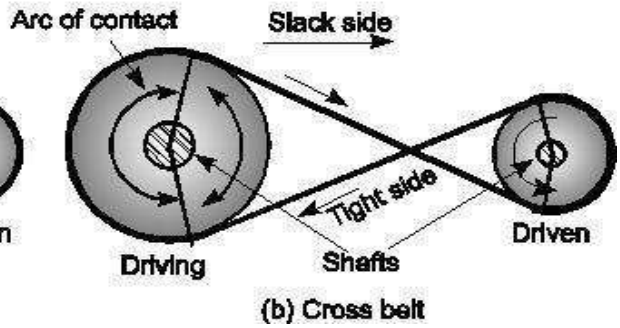


Flat Belt (need joint , long c/c distance)

V- belts (endless , short c/c distance)

Open and cross belt drive

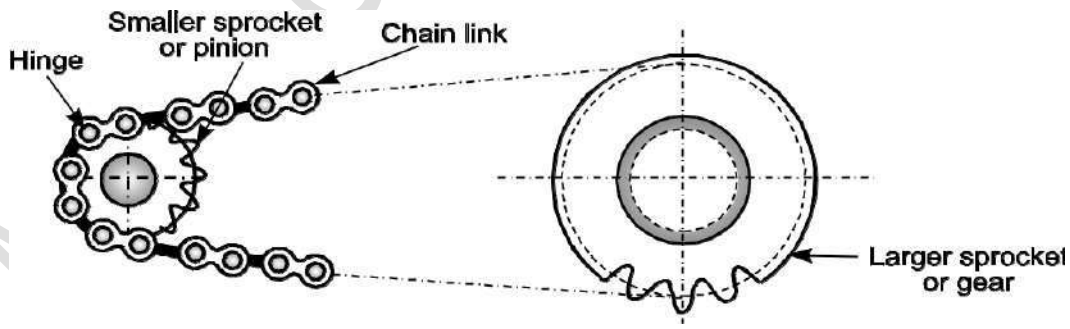




Comparison between Flat and V-belts

	Flat Belt	V-belt
1	Rectangular cross section, need joint, made of fabric, Flat crowned simple pulleys are used	Trapezoidal cross section, endless as no joint, made of Fabric, rubber & steel wires inside, multiple V-grooves on pulleys
2	Used for distance up to 10 m	Used for very small distance.
3	Efficiency of transmission is high about 98%.	Efficiency of transmission is lower, 80% - 96% due to more friction with pulley.
4	Belts Slips is more on pulley	Slip is very less due to wedging between v-belt & grooved pulley
5	The construction is simple.	The construction is difficult and costly.
6	Cheaper in initial and repair costs	Costly to make and repair is not possible, replace with new one.
7	Suitable for moderate power transmission	Suitable for high power transmission; multiple V-belts on same pulleys
8	It cannot give constant velocity ratio because of slip.	It proves constant velocity as slip does not exist.

6. Chain drive : It consists of endless metallic chain running around two sprocket wheels. It is widely used in bicycles, Motor Cycles, Conveyors, Agriculture machinery, Rolling mills, Machine tools, etc



Advantages of Chain Drive :

- It is positive drive
- Used for long as well as short centre distance
- Transmit large power, less expensive than gears
- Can operate at high temp & compact compared to belt drive

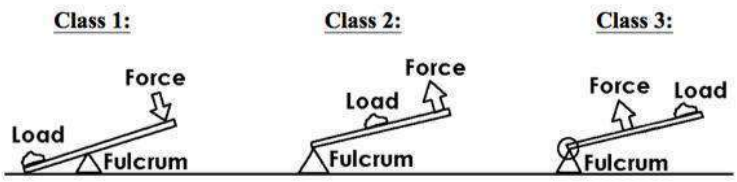
Limitations of Chain Drive :

- Not suitable for precision motion
- Requires lubrication & maintenance
- Noisy operation

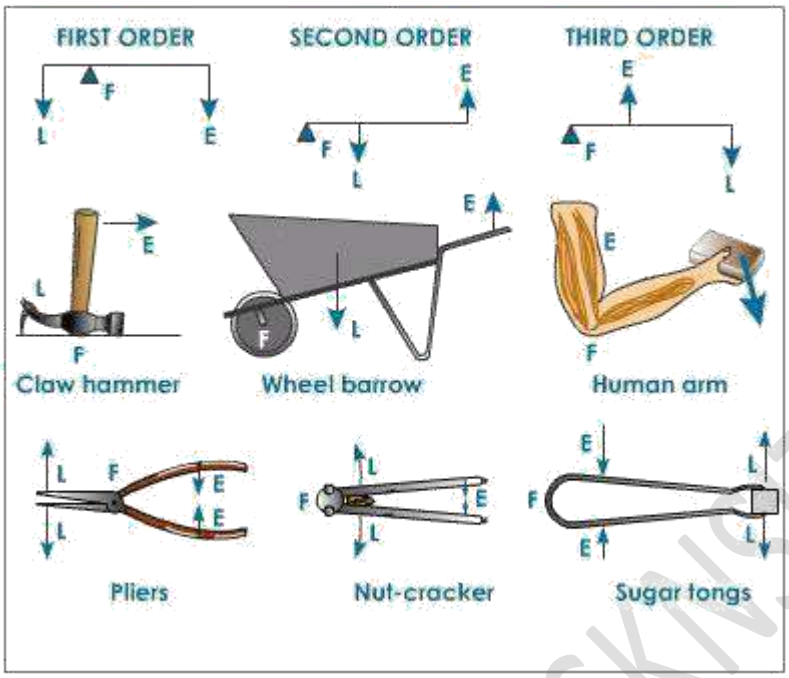
Comparison between Belt , Chain and Gear Drives :

SNo.	Comparison Parameter	Belt Drive	Chain Drive	Gear Drive
1	Type of drive	Non positive	Positive	Positive
2	Elements of drive	Belt, Driving & driven pulleys	Chain, Driving & driven sprocket	Pinion & Gear
3	Used for	Long centre distance	Short & medium CD	Very short CD
4	Axes of Shaft -position	Parallel	Parallel	Parallel, Non-intersecting, Perpendicular & Intersecting
5	Ability to absorb shock	Can absorb shock	Can absorb shock	Cannot absorb shock
6	Cost	Low	Medium	High
7	Space requirement	More	Medium	Less
8	Suitable for high speed	Not suitable	Not suitable	Suitable
9	Lubrication	Not required	Periodically required	Continuously required
10	Power transmission capacity	Moderate to low	Moderate	High

7. Levers - The lever is a movable bar that pivots on a fulcrum attached to a fixed point. The lever operates by applying forces at different distances from the fulcrum, or a pivot. Lever is a simple machine. The power into the lever must equal the power out of the lever. Depending on the position of fulcrum, load and (Effort) force applied, Levers are classified in three categories as given below :



Ideal Machine Efficiency =1 = MA/VR	Class/Order 1	Class/Order 2	Class/Order 3
	F is between L & E	F at one end, L is near to F than E	F at one end, E is near to F than L
VR=MA	1<MA<=1	MA > 1 always	MA < 1 always



Mechanical Advantage (Leverage) by using Lever = _____ =_____ ;

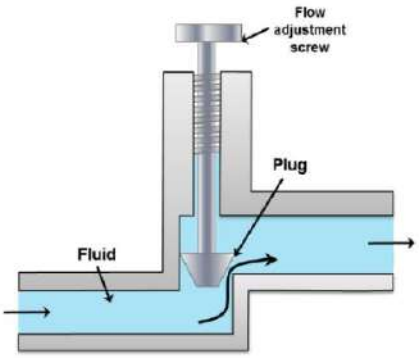
Velocity Ratio (VR) = _____ =_____

Efficiency (ideal machine) = 1 = _____ = _____ =

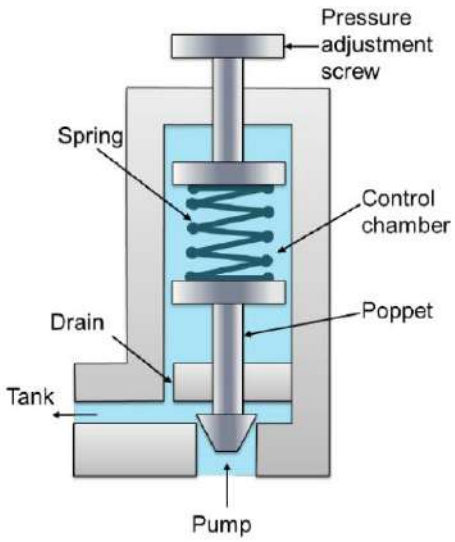
_____ = ___

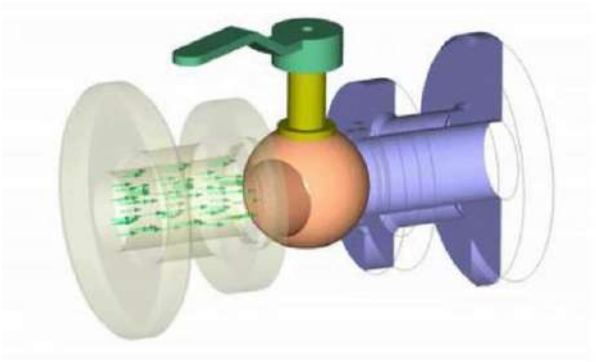
8. Valves : These are mechanical devices that controls flow of fluid by opening or closing.

Flow control valve



Pressure control valve





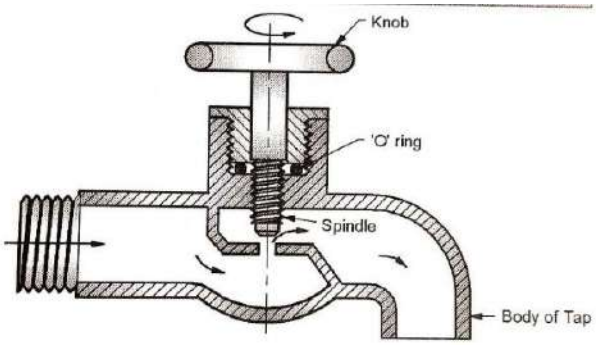
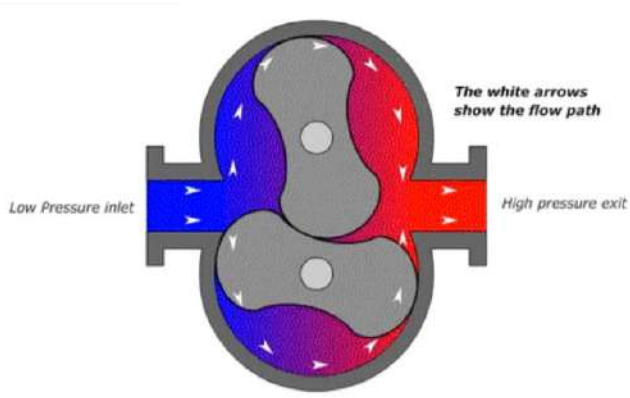


Fig. 6.14.1 : Water Tap [Refer Color Pic.C.6.11]

Centrifugal Fan / Blower



Twin Lobe Roots Blower (Positive Displacement)

Unit 6 : Applications of Mechanisms & Machines

1. Applications of Motors – Washing Machines
2. Applications of Pumps – Water filter/ Purifier
3. Applications of Blowers – Vacuum cleaner , Kitchen Chimney
4. Applications of Compressors – Refrigerator , Water Cooler, Split AC units
5. Applications of Gears – Wall Clocks, Watches, Printers
6. Applications of Valves – Water Taps
7. Applications of Electric / Solar Energy - Geyser, Solar Water Heater, Electric Iron
8. Applications of Springs – Door Closure, Door Locks
9. Applications of Levers – Door Latch, Brake Pedals, etc.
10. Applications of Belt- Pulley/ Chain- Sprockets – Photocopier, Bicycle, etc.

Explain the working of **Washing Machine** with neat well labelled diagram.

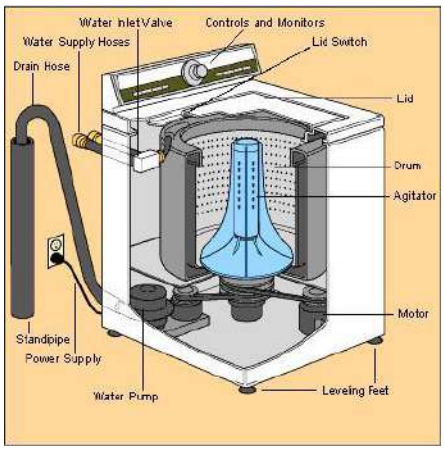
Washing machine is the machine used to wash the various types of clothes without applying any physical efforts. With washing machine you don't have to rub the clothes with hand or squeeze them to remove the water from them. The washing machine is also called as clothes washer or simply the washer.

Washing machine works on the principle of both laws of physics namely centripetal and centrifugal force. **Rinse** cycle is when centripetal force comes into action where force comes from outside to inside to drain the soapy water and render water free zone inside the machine.

The principle behind the **spinning dry** of the clothes in a washing machine is centrifugal force. The fast spinning around of the clothes in the drum creates a large centrifugal force from centre to the edge of the drum, and the wet clothes are flung outwards to the drum edge and the water escapes through the drum holes.

Spinner of washing machine works on the principle of Centrifugation. In this process, the spinner is spun rapidly with great speed which helps to separate the water particles from the wet clothes.

There is a control panel and settings of various programs of washing cycles. Depending on the manufacturer variety of techniques are used to operate Rinse and Spin Cycles such as fuzzy logic & other automation programs. There are inlet hot/cold water, drain, Timers (mechanical /electronic), Sensor such as weight of clothes, detergent check in drain, Lid open, etc.



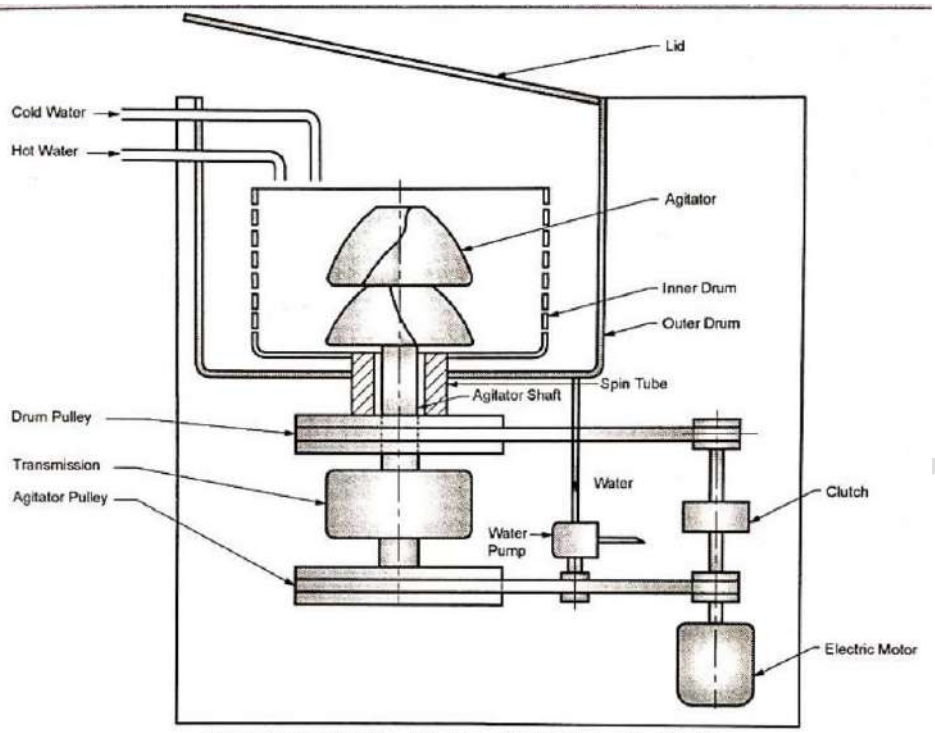
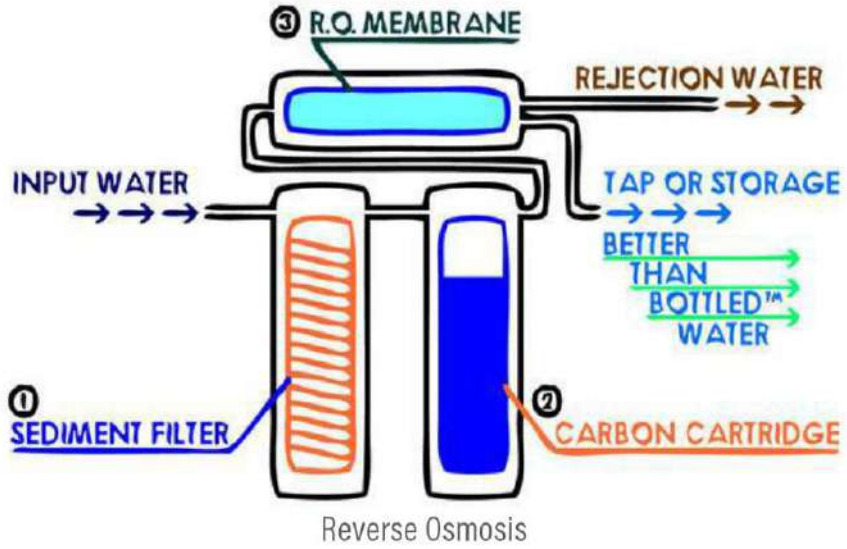
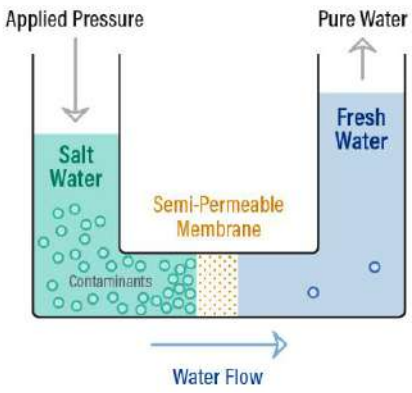


Fig. 6.16.3 : Washing Machine [Refer Color Pic.C.6.13]



Reverse Osmosis



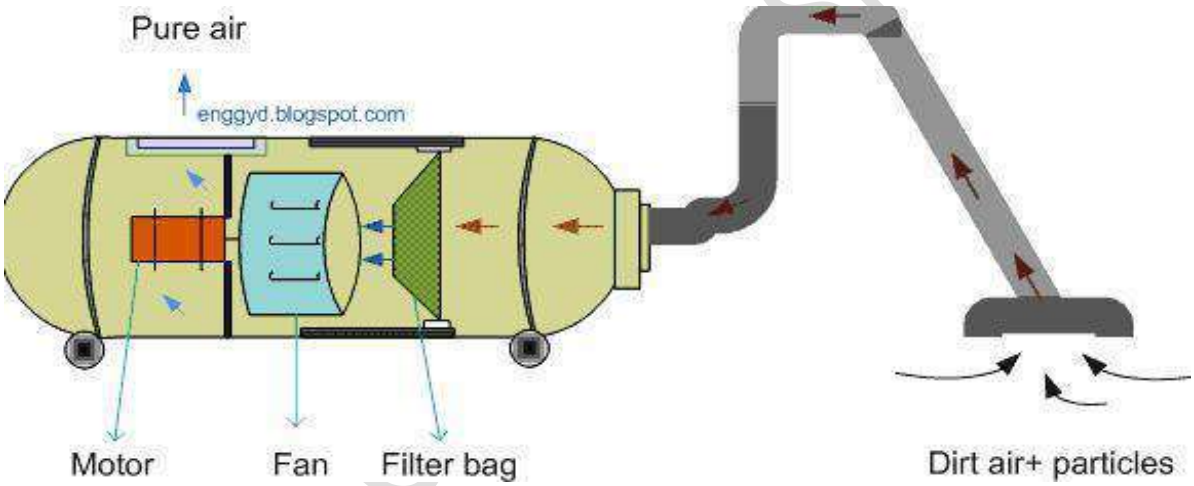
Explain the working of **Water purifier** with neat well labelled diagram.

Water purification is the process of removing undesirable chemicals, biological contaminants, suspended solids and gases from contaminated water. The goal is to produce water fit for a specific purpose. They typically consist of several steps in the treatment process. These include:

(1) Collection ; (2) Screening and Straining ; (3) Chemical Addition ; (4) Coagulation and Flocculation ; (5) Sedimentation and Clarification ; (6) Filtration ; (7) Disinfection ; (8) Storage ; (9) and finally Distribution.

The filtration system includes passage of water or other solvents through a semi-permeable membrane. The membrane blocks the dissolved solutes that contaminate water. The process filters out all sorts of contaminants such as ions, pesticides, micro-organisms and other chemicals from water.

Reverse Osmosis filtration system works by forcing water through a special fine membrane to eliminate impurities that may not be visible to the naked eye. These membranes remove impurities based on their size and shape. This means that particles larger than water molecules cannot pass through the filter.



Vacuum Cleaner

A vacuum cleaner, also known simply as a vacuum, is a device that causes suction in order to remove debris from floors, upholstery, draperies and other surfaces. It is generally electrically driven. The vacuum cleaner uses an electric motor that spins a fan, sucking in air and any small particles caught up in it and pushing it out the other side, into a bag or a canister, to create the negative pressure. It works on the principle of flow of air from area of high pressure to area of low pressure. An electric motor is attached to a fan that spins it at high velocities. The fast spinning fan creates a region of low pressure inside the suction hose of the vacuum cleaner. The accompanying further verifies the significance of vacuum cleaner.

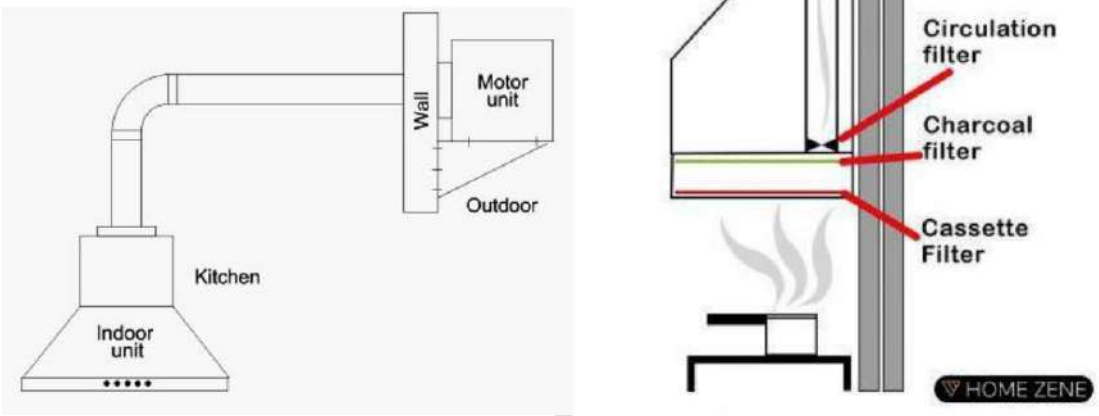
A vacuum cleaner likewise ensures your well-being. Vacuum cleaners expel soil, dust, pet hair and other undesirable particles noticeable all around and in the surfaces of your home. Some vacuum cleaner has the capacity to wash and shampoo carpets.

Explain the working of Kitchen chimney with neat well labelled diagram.

An electric chimney sucks the air inside the kitchen. The air then passes through the filters which absorbs the heat and traps the grease particles thereby removing fumes and odor and ventilates your kitchen keeping it fresh and odor free. Well, Chimney is the need of every house. It is the heart of Chimney. It absorbs all the particles of grease as well as grime and makes your home fresh. That is why it is necessary for Kitchen.

- **Air-cooled Chimneys** – These are chimneys that have multiple layers of metal with air flowing between them.
- **Double-wall Chimneys** – This type has double/twin layers of metal, often stainless steel.

For Indian kitchens, a chimney with higher air suction capacity is ideal. For frequent cooking, the range should be between 400 m3/hr to 1000m3/hr depending on the size of your kitchen. Multiply the volume of your kitchen (in m3/h) by 10 to arrive at the ideal suction power for your chimney.



Kitchen chimney

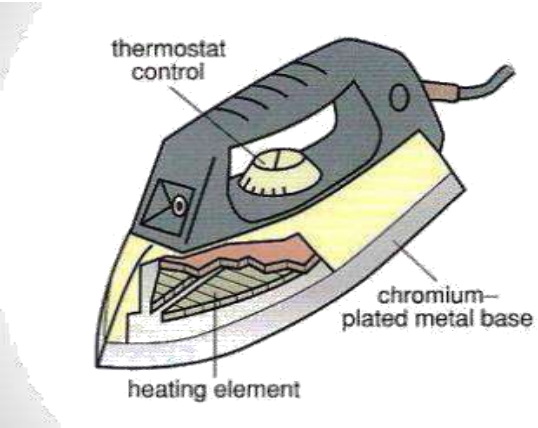
Explain the working of **Electric Geyser/Electric Iron** with neat well labelled diagram.

Electric Iron

An electric iron has a handle and a flat triangle shaped surface. Electricity makes the flat surface hot. A hot iron is rubbed on clothes to make them flat and smooth. This is called ironing. They are named clothes irons because they used to be made out of the metal iron. The iron is the small appliance used to remove wrinkles from fabric. There are basically two types of electric irons:

1. Automatic and
2. Non-Automatic.

The thermal energy produced by an electric iron is spread evenly over a large surface usually a metal base that conducts heat well. The heating element is wound round a flat sheet of mica and sandwiched between two thin insulating sheets. The metal base is chromium plated to make it smoother and withstand wear. It contains a thermostat which switches the current off when they get too hot.



Components of Electric Iron

1. Nichrome Coil
2. Mica Sheets (insulator but good conductor of heat)
3. Steel Base Plate and Body

Heat Generated by coil –

$H = I^2 R t = VI t$

Specs of an Electric Iron:

Wt : 1.06 kg, Voltage : 220-240 V,

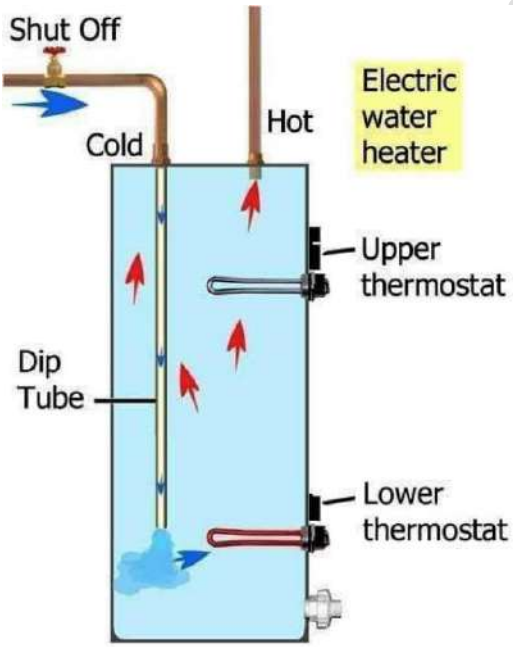
Frequency : 50 Hz, Power : 1440 W

Electric Geyser

The principle on which the geyser works is simply the conversion of electrical energy into heat through the use of heating elements to raise the temperature of water through conduction of the heat to the water. Both the heating elements do not function simultaneously.

An electric water heater thermostat tells the heating elements when to heat up. Most electric hot water tanks have two elements and two thermostats.

The upper thermostat acts as a coordinator between the two elements. When the water in the top part to the tank is hot enough, it lets the lower thermostat go into action.



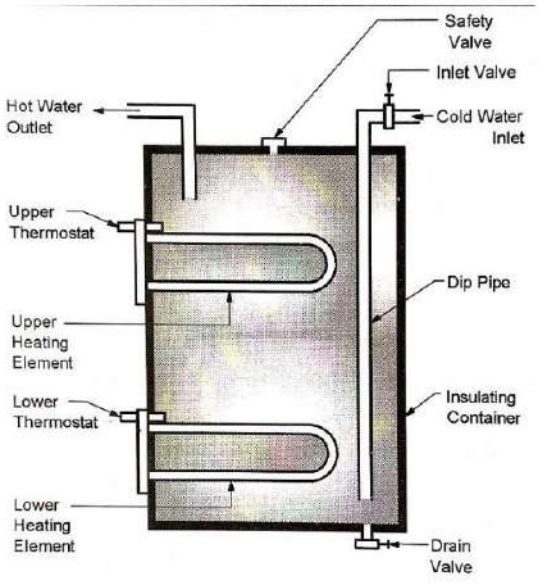


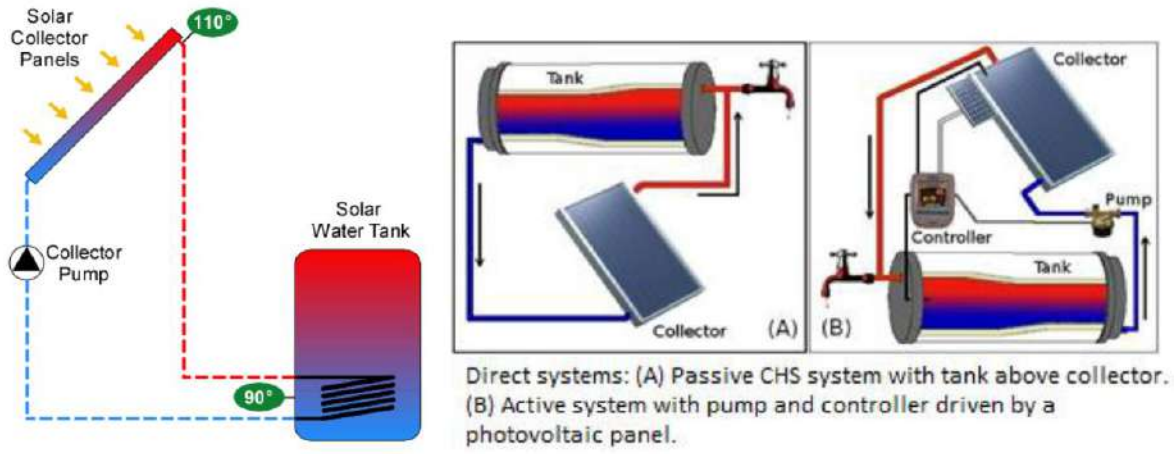
Fig. 6.23.2 : Electric Geyser [Refer Color Pic.C.6.18]

Electric Geyser Specification (Typical):

Tank Capacity : 15 liters

Voltage : 220 – 240 V, Frequency : 50 Hz, Power : 2000 W (2 Heating Elements)

Standing Loss : 0.45 KWh / 24 hours



Direct systems: (A) Passive CHS system with tank above collector. (B) Active system with pump and controller driven by a photovoltaic panel.

Solar water heating (**SWH**) is the conversion of sunlight into heat for water heating using a solar thermal collector. SWHs are widely used for residential and some industrial applications.

A sun-facing collector heats a working that passes into a storage system for later use. SWH are active (pumped) and passive (convection-driven). They use water only, or both water and a working fluid. They are heated directly or via light-concentrating mirrors. They operate independently or as hybrids with electric or gas heaters. In large-scale installations, mirrors may concentrate sunlight into a smaller collector.

Direct or *open loop* systems circulate potable water through the collectors. They are relatively cheap.

Indirect or *closed loop* systems use a heat exchanger to transfer heat from the "heat-transfer fluid" (HTF) fluid to the potable water.

There are 3 types of solar hot water system to choose from:

- **Flat plate collector** : It consists of an insulated box with a glass lid, containing number of copper tubes connected between inlet and outlet headers. These tubes are painted with black to absorb maximum heat. Water is circulated in tubes get heated & it moves up to storage tank. A flat plate collector is at its most efficient only when the sun is directly above the panel. Normally it is kept inclined and facing South to get max exposure.
- **Evacuated tube collector:** Evacuated Tube Collectors collect the heat through a number of annealed glass tubes that each have their own heat-absorbing plate inside. A vacuum (which is an excellent insulator) is created during manufacturing between the outer and inner glass tubes, this makes for a very efficient solar heater used to heat either the water directly, or a special heat transfer fluid that transfers the heat to the water. As the tubes are round, not flat, means that they can efficiently collect heat no matter where in the sky the sun is.
- **Heat pump systems** : A Heat Pump operates on electricity but five times more efficient than normal electric heater. It does not need any panel on roof and can operate in any season or any time of the day/night. It's evaporator coil takes heat from atmosphere and the compressor pushes/pumps it to the condenser coil to heat the water. It is basically a refrigeration circuit used for heating ; has a compressor, a condenser, a throttle/ expansion valve and an evaporator.

Application of Compressors :

Refrigeration

Unit of Refrigeration -1 ton of refrigeration TR is capacity to freeze (make ice) one short ton of water at 0°C in 24 hours.

1 tone refrigeration = 3.517 KW

Example of " Specifications of Refrigerator " :

Capacity of refrigerator	-	165liters
Refrigerant used	-	R134a
Compressor Capacity	-	1/7 HP Hermetically sealed.
Condenser		
Length	-	8.5m
Diameter	-	6.5mm
Evaporator		
Length	-	7.62m
Diameter	-	6.5mm
Capillary tube		
Length	-	2.128m
Diameter	-	0.8mm

Refrigeration: The process of keeping an item below room temperature by storing the item in a system [VCRS] or substance designed to cool or freeze. The most common form of refrigeration is provided by systems (i.e. refrigerators) that use a refrigerant chemical to remove heat from items stored inside the system.

The purpose of the compressor is to circulate the refrigerant in the system under pressure, this concentrates the heat it contains. Compressor change the low-pressure gas is into high pressure gas. For Effective cooling or refrigeration effect there is need of High-Pressure refrigerant at inlet of expansion device this is achieved by Compressor.

Refrigerator/Freeze: Refrigerator is an appliance that cools an area, generally for food, beverage or vaccine storage. Refrigerators lower the temperature, and therefore, even evaporative coolers can be considered refrigerators. Many refrigerators also include a freezer, and are often referred to as "fridge/freezers".

Refrigerant: A refrigerant is a substance or mixture, usually a fluid, used in a heat pump and refrigeration cycle. In most cycles it undergoes phase transitions from a liquid to a gas and back again. Many working fluids have been used for such purposes.

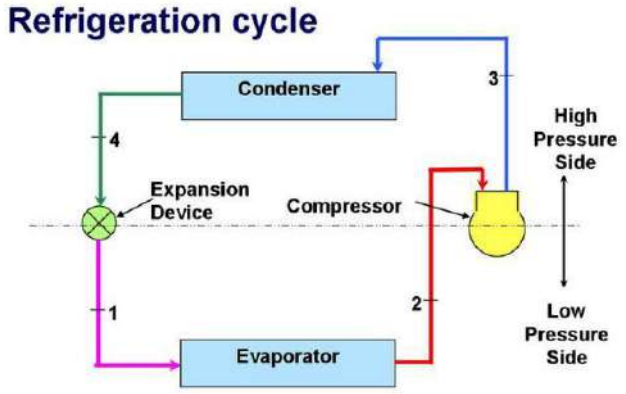
As per the various manufacturers' guidelines, there are four main refrigerant types: CFCs – Chlorofluorocarbons. HCFCs – Hydro chlorofluorocarbons. HFCs – Hydro fluorocarbons. Natural Refrigerants like CO2, Ammonia, etc

Modern refrigerators usually use a refrigerant called HFC-134a (1,1,1,2-Tetrafluoroethane), which does not deplete the ozone layer, instead of Freon.

Explain the working of Domestic Refrigerator and the steps in Vapour Compression Refrigeration Cycle.

The Vapor Compression Refrigeration Cycle involves four components connected in a close circuit pipeline containing refrigerant: 1) compressor, 2) condenser, 3) expansion valve/throttle valve and 4) evaporator.

A detailed explanation of the steps in Vapour compression Cycle is as below :



STEP 1: COMPRESSION

The refrigerant (for example R-134) enters the compressor at low temperature and low pressure. It is in a gaseous state. Here, compression takes place to raise the temperature and refrigerant pressure. The refrigerant leaves the compressor and enters to the condenser as high pressure vapour. Since this process requires work, an electric motor may be used. Compressors can be of type such as scroll, screw, centrifugal or reciprocating types.

STEP 2: CONDENSATION

The condenser is essentially a heat exchanger. Heat is transferred from the hot refrigerant to a flow of surrounding air. As the refrigerant flows through the condenser, it looses some of its heat but remains at a constant pressure.

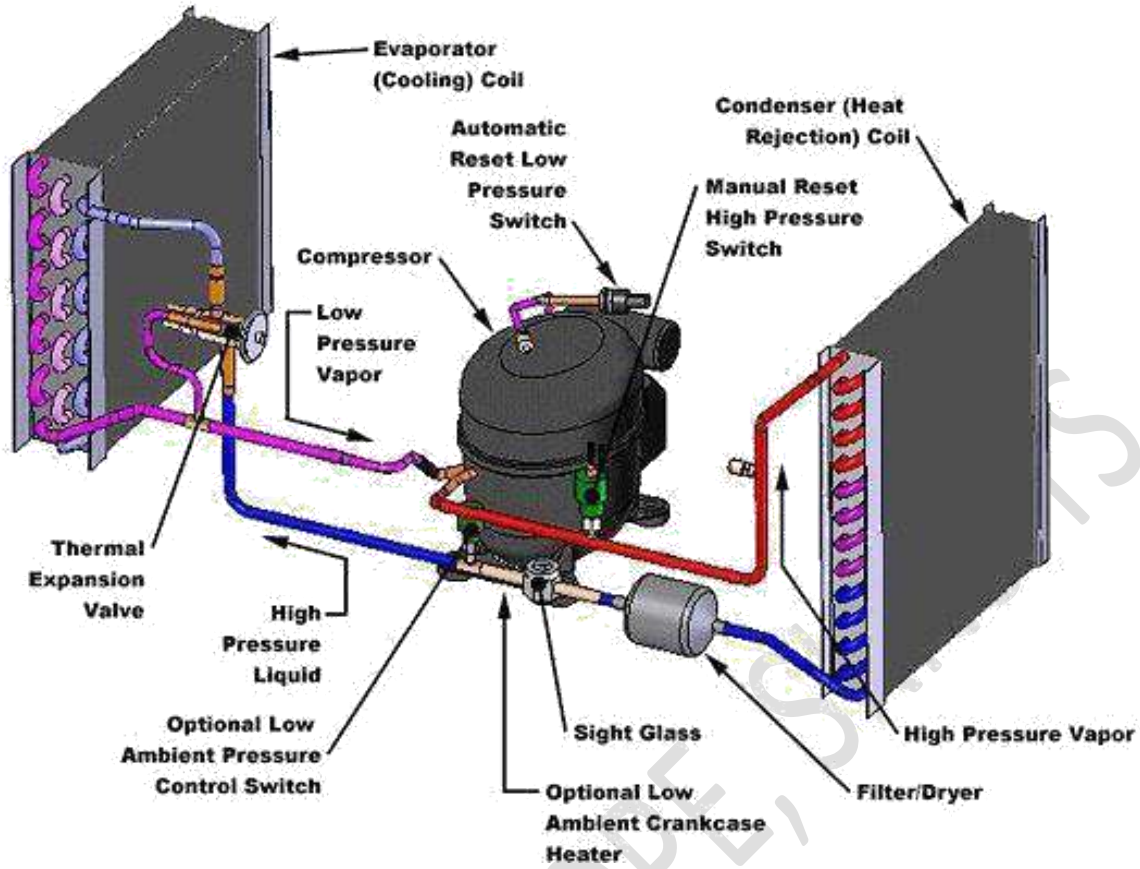
STEP 3: THROTTLING (sudden expansion of high pressure refrigerant)

When the refrigerant enters the throttling valve or capillary tube, it expands and releases (lowers) its pressure. Consequently, the temperature drops at this stage. (Press/temp = Constant). Because of these changes, the refrigerant leaves the throttle valve as a liquid vapour mixture, typically in proportions of around 75 % and 25 % respectively.

Throttling valves play two crucial roles in the vapour compression cycle. First, they maintain a pressure differential between low- and high-pressure sides. Second, they control the amount of liquid refrigerant entering the evaporator.

STEP 4: EVAPORATION [REFRIGERATION EFFECT]

At this stage of the Vapor Compression Refrigeration Cycle, the refrigerant is at a lower temperature than its surroundings. Therefore, it evaporates and absorbs latent heat of vaporization. Heat extraction from food/frozen space by the refrigerant happens at low pressure and low temperature. The refrigerant evaporates (as it absorbs heat) to low pressure vapour & then flows back to the compressor, where the cycle starts all over.



In the refrigeration cycle, Vapour compression refrigeration system (VCRS,)there are five basic components: fluid refrigerant; a compressor, which controls the flow of refrigerant; the condenser coils (on the outside of the fridge); the evaporator coils (on the inside of the fridge); and something called an expansion device. Here's how they interact to cool your food.

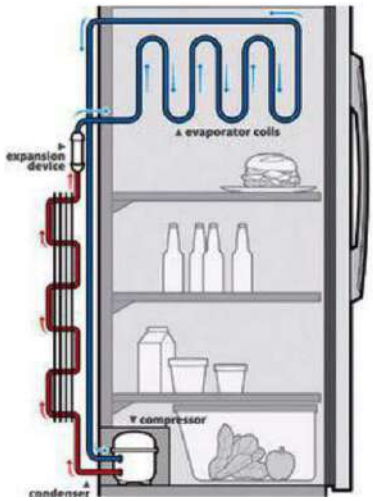
1. The compressor constricts the refrigerant vapor, raising its pressure, and pushes it into the coils on the outside of the refrigerator.----in Condenser 2. When the hot gas in the coils meets the cooler air temperature of the kitchen, it becomes a liquid. 3. Now in liquid form at high pressure expands through capillary tube i. e. expansion valve, the refrigerant cools down as it flows into the coils inside the freezer and the fridge. 4. The refrigerant absorbs the heat inside (Evaporator) the fridge, cooling down the air. 5. Last, the refrigerant evaporates to a gas, then flows back to the compressor, where the cycle starts all over.

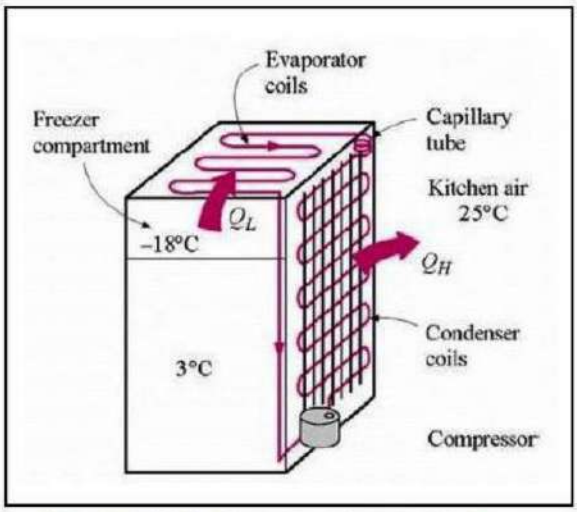
What are the applications of refrigeration?

For convenience of study, refrigeration applications may be grouped into six general categories:

1. Domestic refrigeration.
2. Commercial refrigeration.
3. Industrial refrigeration.
4. Marine and transportation refrigeration.

1. Comfort air conditioning
2. Industrial air conditioning





Household Refrigerator Cooling Cycle

What is air conditioning? Explain the different types of air conditioning.

Air conditioning (often referred to as AC, A/C, or air con) is the process of removing heat and moisture from the interior of an occupied space to improve the comfort of occupants. Air conditioning can be used in both domestic and commercial environments.

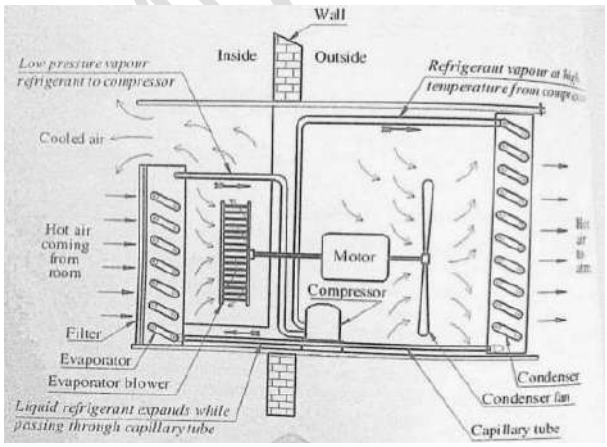
A system for controlling the humidity, ventilation, and temperature in a building or vehicle, typically to maintain a cool atmosphere in warm conditions and vice versa.

An air conditioner is a system or a machine that treats air in a defined, usually enclosed area via a refrigeration cycle in which warm air is removed and replaced with cooler air.

In construction, a complete system of heating, ventilation, and air conditioning is referred to as HVAC.

Types of Air conditioning Systems:

- Central Air Conditioning
- Ductless, Mini-Split Air Conditioner
- Window Air Conditioner and Split Air Conditioner
- Portable Air Conditioner
- Hybrid Air Conditioners
- Geothermal Heating & Cooling



Explain the working of **Window air conditioner** with neat sketch.

Window and room air conditioners use refrigeration principles to extract heat and moisture from room air, cooling and dehumidifying the air. The basic components inside the unit include a blower and/or fans for moving cooled air into the room and exhausting warm air, and refrigerant components for extracting heat from the air.

Those components include a compressor, evaporator coil, refrigerant-filled tubing, and condenser coil. Most window and room air conditioners have thermostatic controls.

How Does a Window or Room Air Conditioner Work?

1. **Room temperature** reaches the thermostat's set point, turning on the room or window air conditioners blower. This draws room air through the air inlet grille and a filter that removes airborne dust and particles.

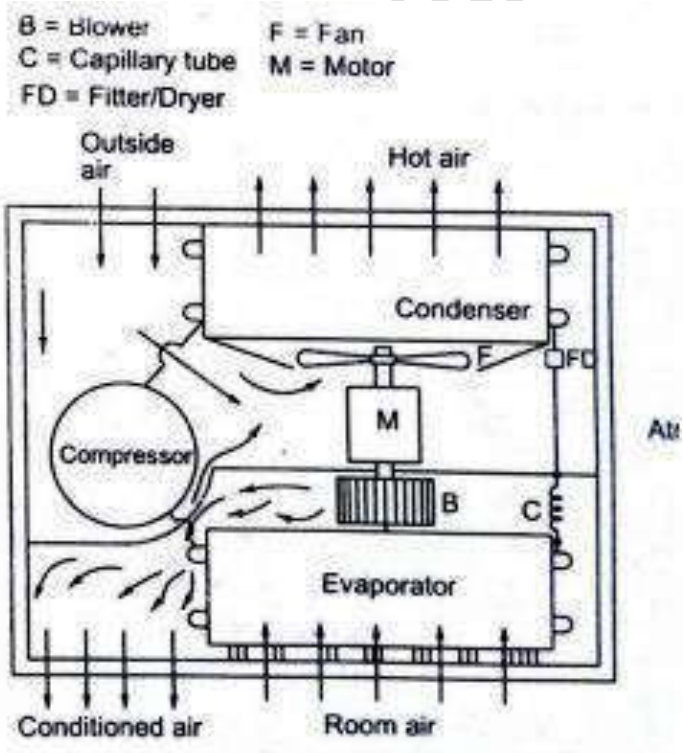
2. Refrigerant is pumped through tubing in the unit, initiating the refrigeration process. This refrigerant takes on and gives off heat as it raises and lowers in temperature, changing from liquid to gas and then back to liquid.

3. When the refrigerant begins to circulate through the indoor coil, it is very cold. As the blower pushes warm air across the coil, the refrigerant absorbs heat and turns into vapor.

4. The vapor travels to a compressor that pressurizes it and moves it through the condenser coil, where it gives off heat, which is expelled outside.

5. The refrigerant then moves through an expansion device that converts it to a low-pressure, cool liquid again, which then returns to the evaporator coil.

6. The cycle repeats. All the while, the blower pushes air past the cold coil to chill the air and blow it back into the room.



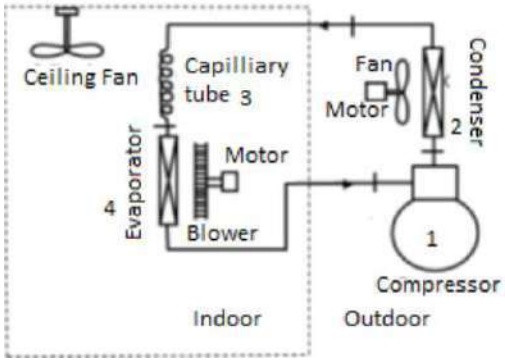
Explain the working of Split air conditioner with neat sketch.

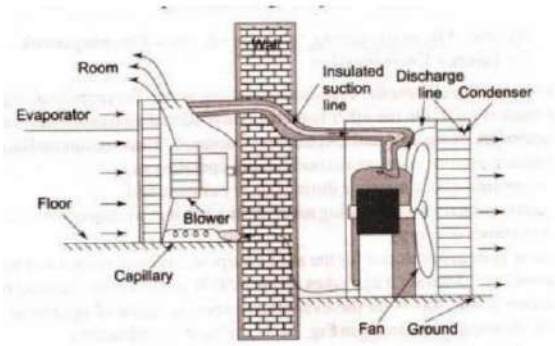
A split air conditioner consists of two main parts – a compressor with condenser are located outside the room and an “air outlet unit” fitted inside the room.

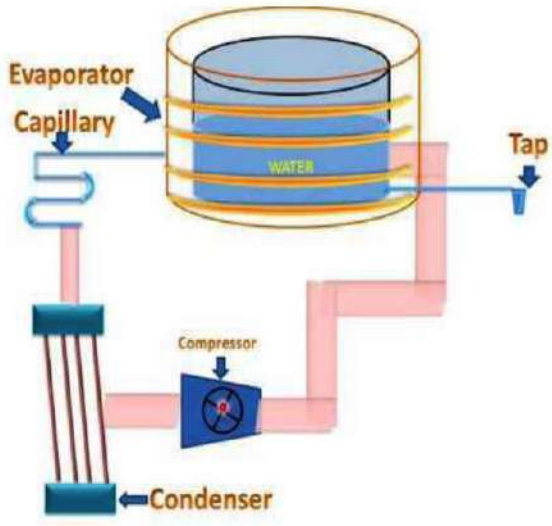
Unlike a system that requires a series of ductwork networked throughout the ceiling, split air conditioners rely on a set of pipes to connect the outdoor to the inside air unit.

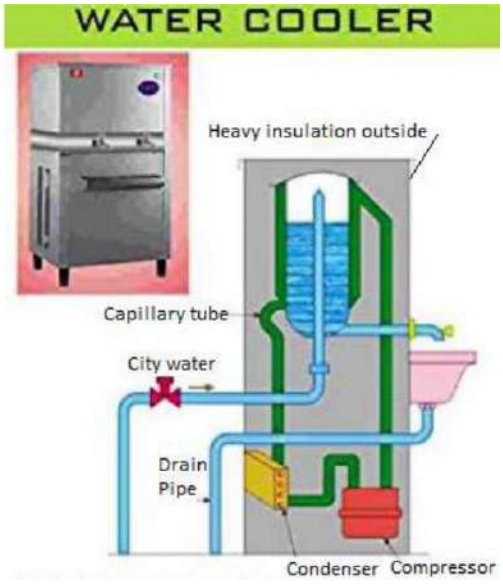
Vapour Compression refrigeration system is used : Condenser and Evaporator Compressor and Expansion valve (Capillary Tube)

The heat from the room is absorbed by the very cold refrigerant and in turn, the air inside the room becomes cool. Compressor (in the outdoor unit of a split air conditioner): It compresses the hot refrigerant gas into a hot liquid refrigerant which is ready to exchange heat from Condenser to surrounding atmosphere.









Water Cooler

Explain the working of Water Cooler with a neat sketch.

In a water cooler, water is fed into a reservoir, where it is cooled using a cold refrigerant in evaporator coil of vapour compression refrigeration cycle. This refrigeration system have 4 main components connected in closed circuit pipeline in sequence as: Compressor , Condenser, Expansion valve (Capillary Tube) and Evaporator.

A refrigerant is a chemical/natural substance circulates in this circuit as working medium and changes its phases to absorb or release heat.

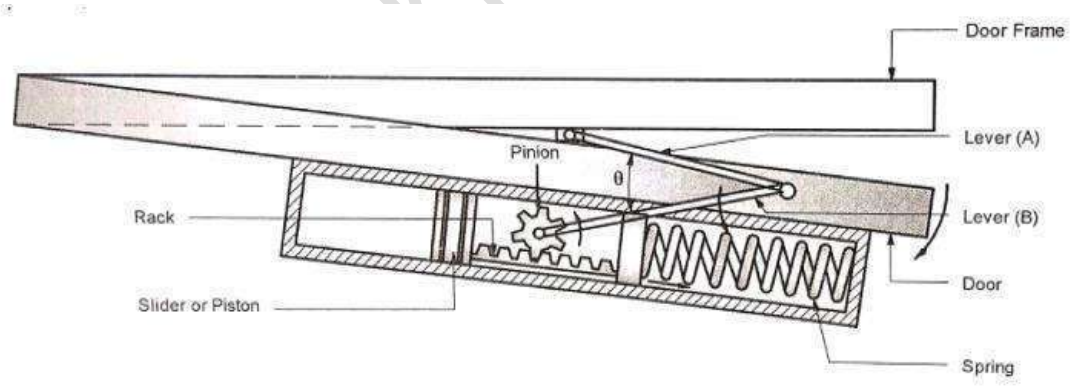
The pressure & temperature of refrigerant is increased by compressor. It becomes hot vapour and passes through Condenser piping which is just a heat exchanger. The refrigerant loses some of its heat to surroundings but its high pressure is maintained.

At the capillary tube or expansion valve or throttle valve, this high pressure vapour is allowed to **expand suddenly**, which lowers its pressure and its temperature also drops proportionately to become lower than surroundings. Refrigerant becomes liquid of low temperature & pressure. It passes through evaporator coil to absorb heat from water cooler's reservoir. Now the refrigerants warms up to room temperature and enters to the compressor to repeat the cycle.

The cooling effect achieved is the amount of heat absorbed by evaporator from the reservoir of the water cooler.

As people dispense water, the machine will refill the reservoir and the process begins again. Should the water reservoir empty completely during dispensing, it will take a few minutes before the water cooler chills the water to a low temperature.

Door Closure Mechanism : It is desired that the door to be closed automatically & smoothly.



Door Closure Mechanism

As door opens, Lever A & B straightens & moves pinion gear anticlockwise to move rack towards the spring makes the spring compress. The energy stored in spring is released as spring expands exerts push force on the rack which makes the pinion rotates clockwise; exerting force on the door to close it.

The sliding rack & pinion provides damping action against the force of spring to close the door smoothly. With only spring the door could be closed but rapidly without control.

6.12.2 Brake Pedal :

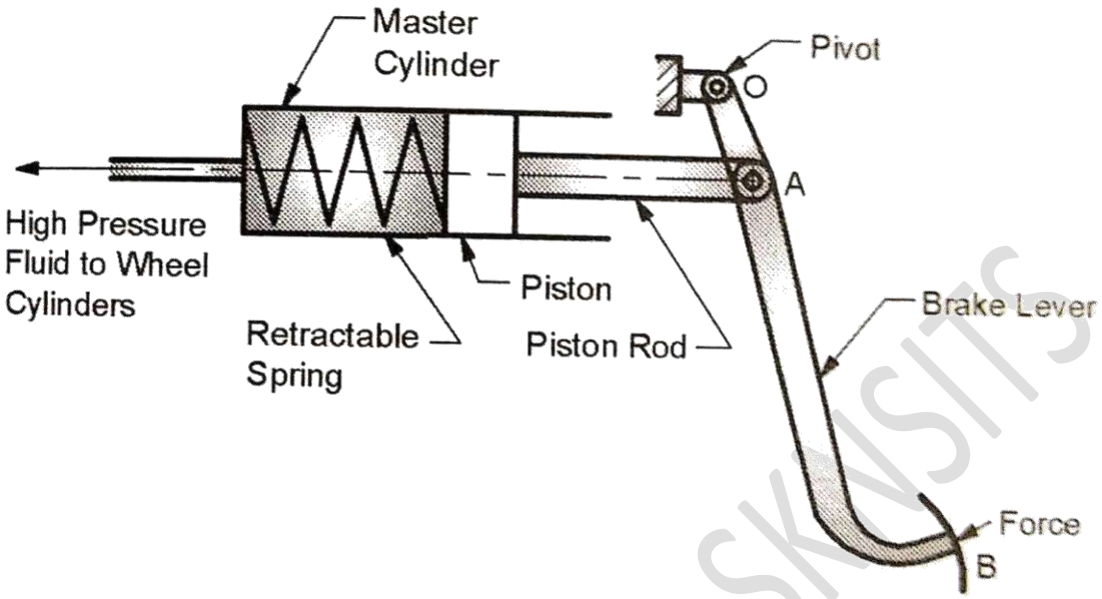


Fig. 6.12.2 : Brake Pedal [Refer Color Pic.C.6.10]

Brake pedal is used in applying brake in vehicles. When braking force is applied, piston rod pushes the piston and increases the pressure of brake fluid in master cylinder.

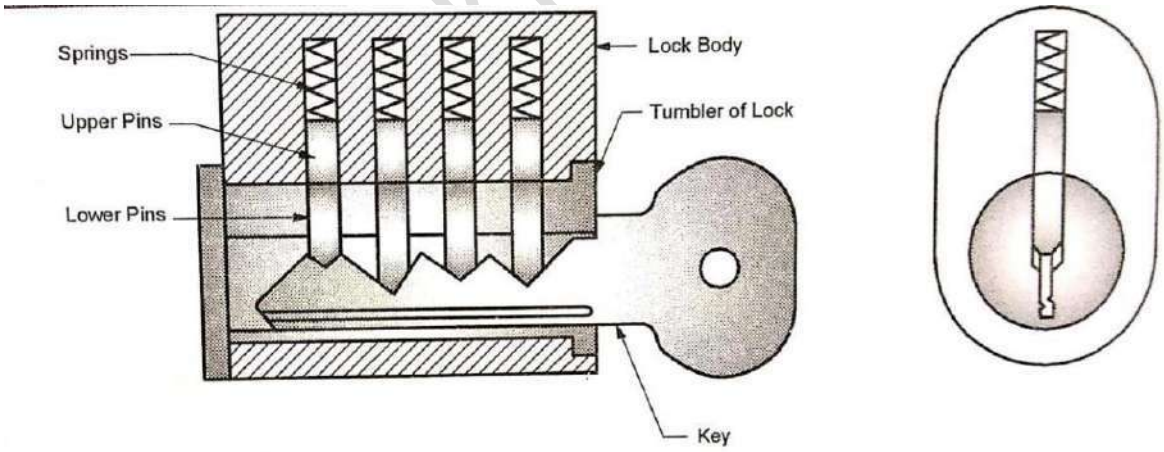


Fig. 6.10.2 : Door Lock [Refer Color Pic.C.6.9]

To open the lock, the tumbler should rotate. When correct key is inserted, profile of the key perfectly adjusts the heights of lower pins such that top surfaces of lower pins matches with tumbler surface and tumbler can rotate with the lower pins and key.

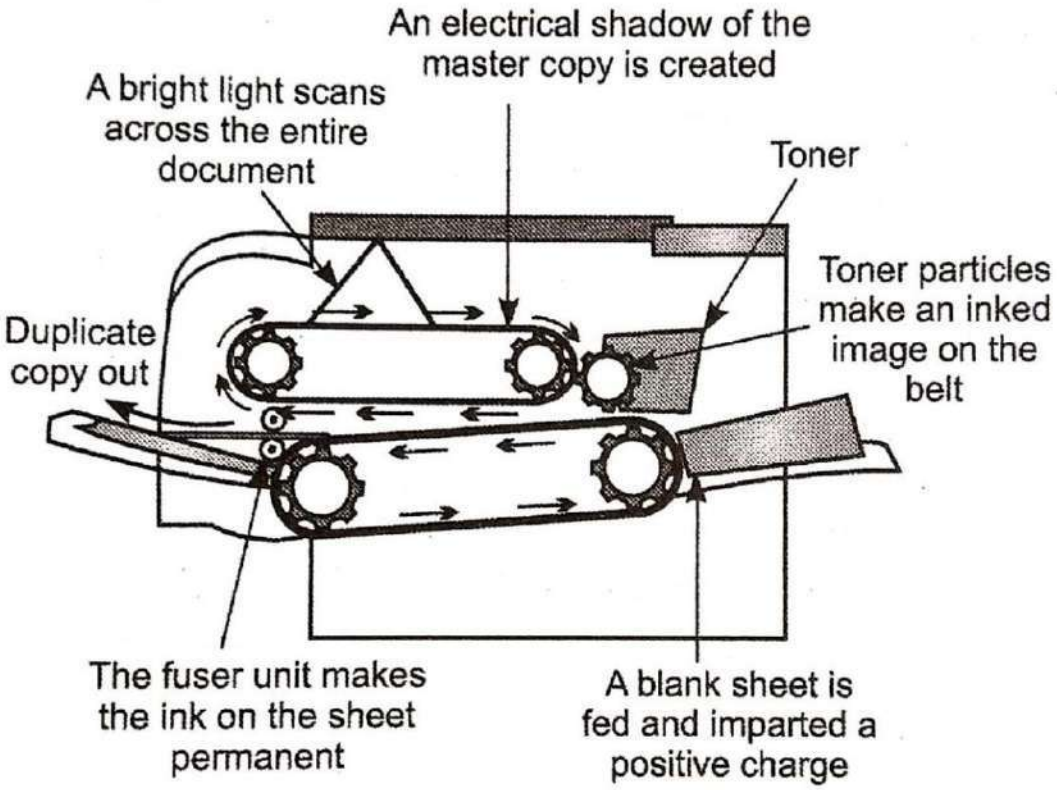


Fig. 6.39 : Belt drive in photocopier machine

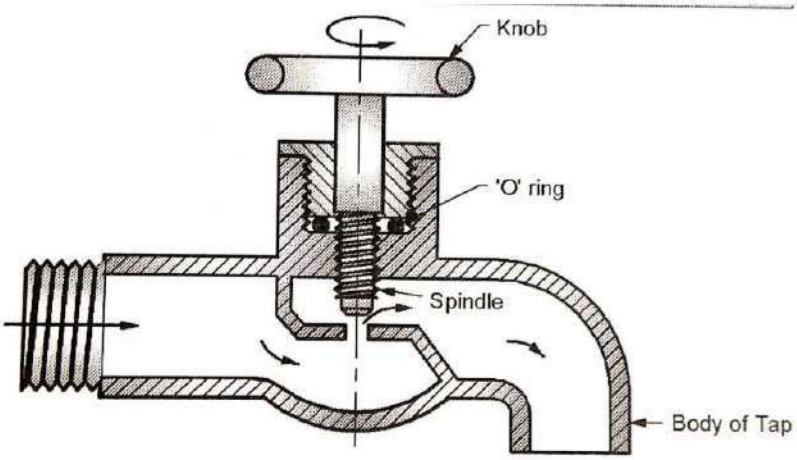


Fig. 6.14.1 : Water Tap [Refer Color Pic.C.6.11]

Valves : Valve is a mechanical device that controls the flow of fluid by opening or closing. An application of valve is Water Tap.

When knob is rotated, spindle moves up and down. Upward movement of spindle opens the water flow; while downward movement of spindle closes the passage of water flow.