Systems in Mechanical Engineering

Unit VI

Engineering mechanisms and their application in domestic appliances

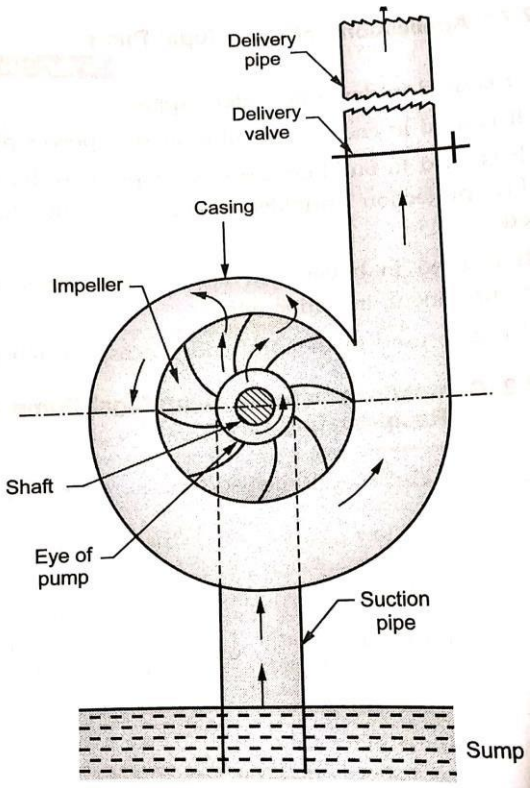
A. Y. 2020-21

- **Specification:** Technical specification of equipment or product are set of performance and physical parameter that equipment or product meet. It is detailed description of requirements, dimensions, material etc.
- **Input:** Input to an equipment is an energy supplied to the equipment (product or machine). The input to any equipment (product or machine) can be in different forms. Electric energy, Chemical energy of fuel, solar energy, Human power.
- **Output:** Output of any equipment is the work done by the equipment (product or machine). The output of any equipment (product or machine) can be in different forms. Tractive effort, Raising or lifting load, increasing pressure, cooling effect, heating effect.
- **Efficiency:** Efficiency is the ratio of output work to input energy.

$$\text{Efficiency of Engine} = \frac{\text{Output Work done}}{\text{Input Energy}}$$

A. Pump

- **Pump** is a mechanical device which convert mechanical energy into hydraulic energy.
- Pump is driven by some prime mover which can be an I. C. engine, steam engine or electric motor.
- In most of cases pump used for raising fluids from a lower level to higher level. This is achieved by creating low pressure at the inlet or suction end and high pressure at the delivery end or outlet of the pump.



Centrifugal pump:

- **Principle**: If the mechanical energy is converted into pressure energy by using centrifugal force acting on the fluid, the hydraulic machine is known as centrifugal pump.
- **Construction:**

1. Impeller: It is mounted on the shaft which is connected to motor. It has series of curved blades.
2. Casing: Impeller is covered in casing with suction pipe connected to eye of the impeller and delivery pipe is connected on other side of it.
3. Suction Pipe: It is pipe whose one end connected to inlet of pump and other dips into water sump. A non-return valve is fitted at the lower end of suction pipe which opens in upward direction only. To remove dust, dirt strainer is fitted at lower end of suction pipe.
4. Delivery Pipe: It is pipe whose one end is connected to the outlet of the pump and other end delivers the water at a desired height. To control flow of liquid a delivery valve is connected to this pipe.

- **Working:**

1. During installation of centrifugal pump, whole pump including casing, impeller, suction pipe and delivery pipe are filled with liquid, it is called as priming of pump.
2. As the motor started, impeller starts rotating because of its rotation the water is thrown into casing because of centrifugal force produced.
3. It tends to create vacuum at the eye of the impeller and causes the liquid to succeed into impeller from liquid sump through suction pipe.
4. As soon as delivery valve opened, the liquid is forced into the overhead tank through delivery pipe.

- **Advantages:**

1. It is small in size.
2. Capital cost is less.
3. It is easy in maintenance.
4. It deals with large volume.
5. It able to work medium to low head.
6. Works with medium to low viscous fluid.

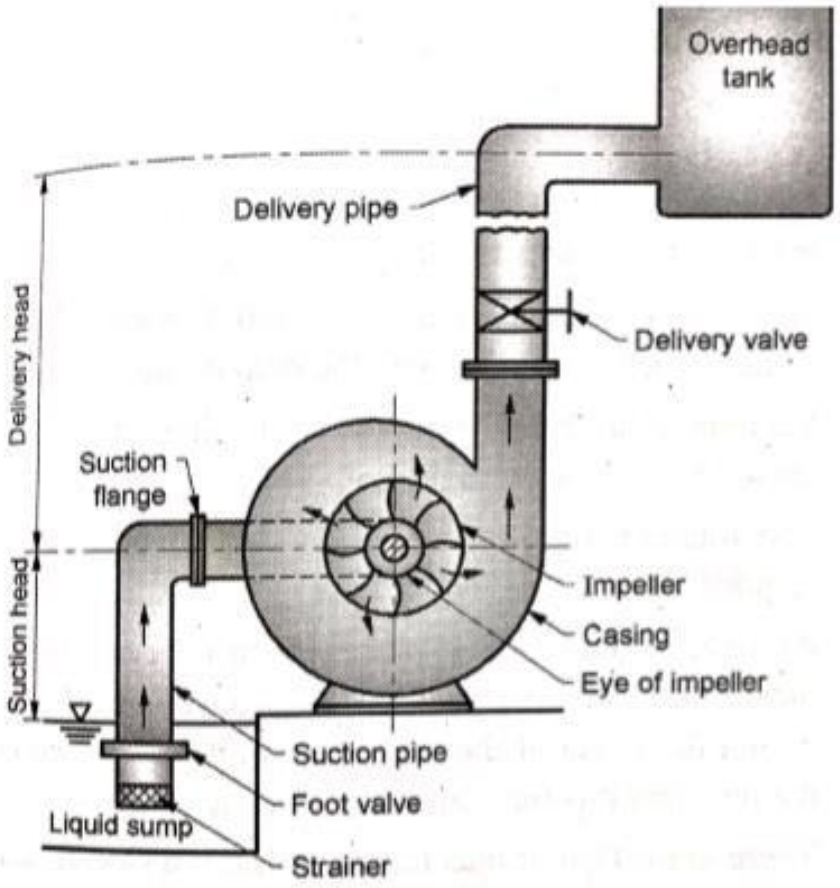
- **Disadvantages:**

1. It's bearing damages due to overheating.
2. It doesn't allow shaft misalignment.
3. It seals Wear rings need to replace from time to time.

- **Applications:**

1. It is used for pumping of sewage and slurries.
2. It is used for pumping of domestic water.
3. It is used in building services for pressure boosting, fire protection sprinkler system, air conditioner etc.
4. It is used in boiler feed applications, water management, irrigation etc.
5. Used in chemical and process industries.

1. Application of pump: Pump for Overhead tank



- **Construction:**

1. Centrifugal Pump: The water pump-set consists of centrifugal pump coupled to an electric motor
2. Electric Motor: Electric motor acts as a prime mover to run the centrifugal pump.
3. Suction Pipe: The suction pipe is connected to an eye of the impeller
4. Delivery Pipe: The delivery pipe is connected to the output of the pump.
5. Foot Valve: Foot valve is not return valve. It avoids flow of water from pump to supply tank.
6. Strainer: Strainer avoids entry of dust, dirt etc. in suction pipe.

- **Working:**

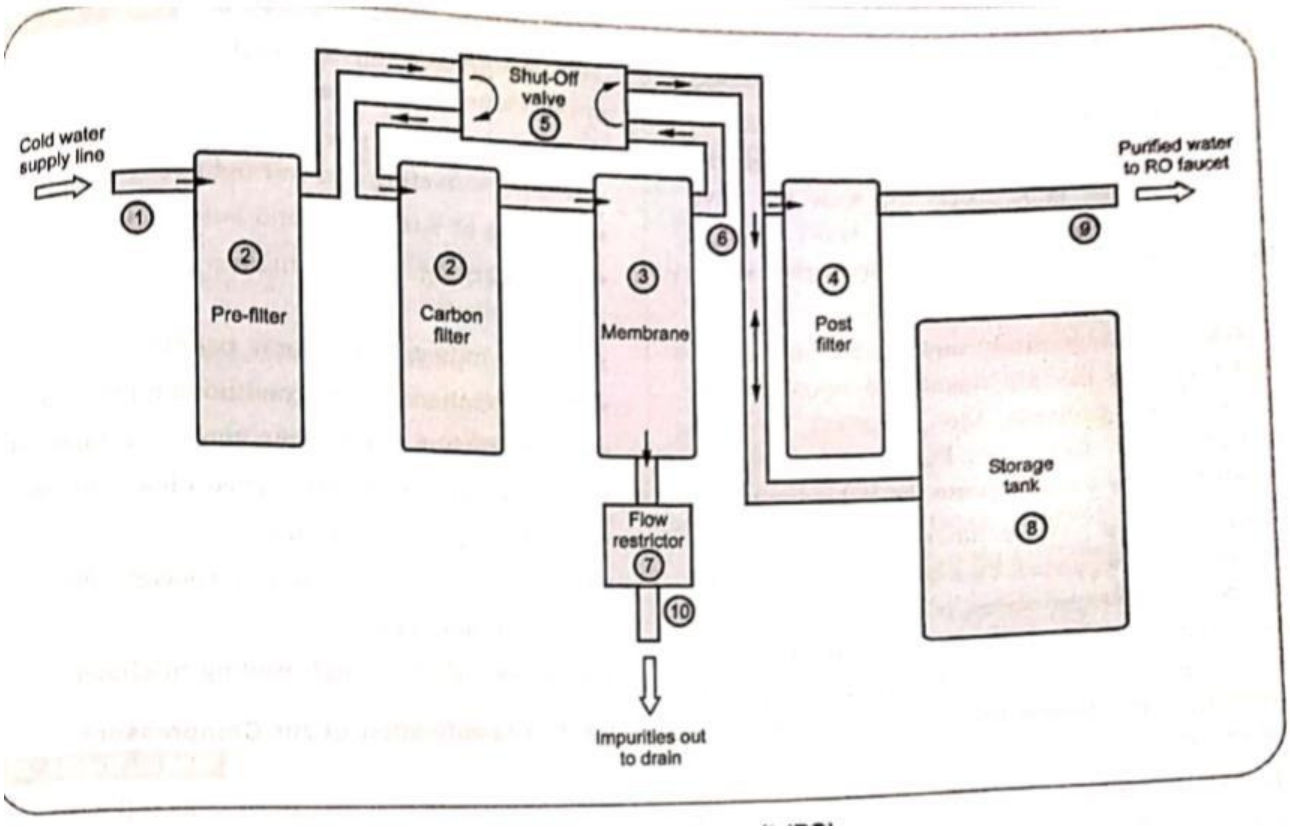
i. The water is lifted form the supply tank to the overhead tank. The height though which the water is lifted is called the head of the pump.

ii. When overhead tank gets empty then water pump will turn ON. When overhead tank gets full or underground tank J gets empty, then pump will turn OFF. When the water levels inside the ground tank or the overhead tank reaches a certain level, the auto control system comes into play and the water pump connected starts or stops.

iii. When the overhead tank is full, the sensor will switch off the system and pump stops working.

2. Application of Pump: Water filter/ purifier Unit:

Water purification is the process of removing undesirable chemicals, biological contaminants, suspended solids and gases from water. Water purification may reduce the concentration of particulate matter including suspended particles, bacteria, viruses and fungi as well as reduce the concentration of a range of dissolved particulate matter.



- The commonly used water filter or purifier unit in India is RO (Reverse Osmosis).Reverse osmosis water purification process is accomplished by water pressure pushing tap water through a semi-permeable membrane to remove impurities from water. This is a process in which dissolved inorganic solids (such as salts) are removed from a solution (such as water).

- Basic components of reverse osmosis system:

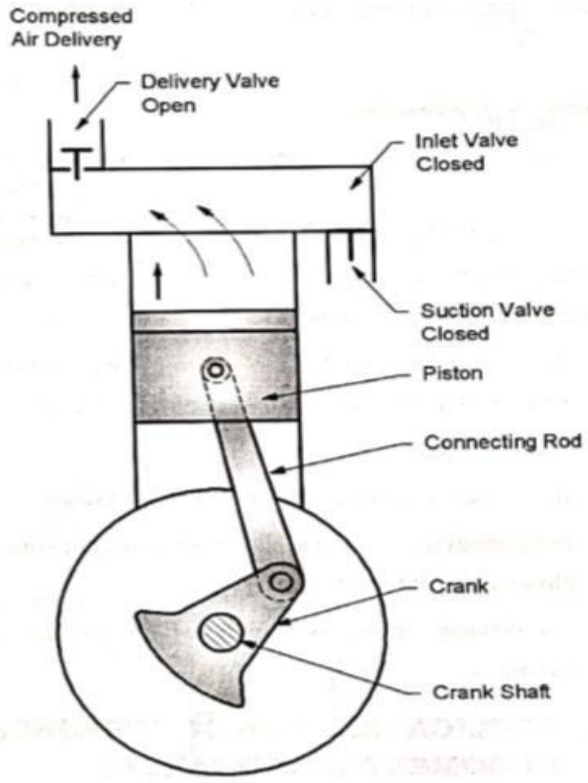
1. Cold water line valve: It is a valve that fits onto the cold water supply line. The valve has a tube that attaches to the inlet side of the RO pre-filter. This is the water source for the RO system.
2. Pre-filters: Water from the cold water supply line enters the reverse osmosis pre-filter first. There may be more than one pre-filter used in a reverse osmosis system, the most common is sediment and carbon filters. These pre-filters are used to protect the RO membranes by removing sand silt, dirt and other sediment that could clog the system. Additionally, carbon filters may be used to remove chlorine, which can damage the RO membranes.
3. Reverse osmosis membrane: The reverse osmosis membrane is the heart of the system. The semi-permeable RO membrane is designed to remove a wide variety of both aesthetic and health-related contaminants. After passing through the membrane, the water goes into a pressurized storage tank where treated water is stored.
4. Post filters: After the water leaves the RO storage tank, but before going to the RO faucet, the treated water goes through a final post filter. The post filter is usually a carbon filter. Any remaining tastes or odours are removed from the product water by post filtration polishing filter.
5. Automatic Shut Off Valve (SOV): To conserve water, the RO system has an automatic shut off valve. When the storage tank is full, the automatic shut off valve closes to stop any more water from entering the membrane and blocks flow to the drain. Once water is drawn from the RO faucet, the pressure in the tank drops; the shut off valve then opens to send the drinking water through the membrane while the contaminated waste water is diverted down the drain.
6. Check valve: A check valve is located in the outlet end of the RO membrane housing. It prevents the backward flow of treated water from the RO storage tank. A backward flow could rupture the RO membrane.
7. Flow restrictor: Water flowing through the RO membrane is regulated by a flow restrictor. Its purpose is to maintain the flow rate required to obtain the highest quality drinking water. The flow restrictor also helps maintain pressure on the inlet side of the membrane.
8. Storage tank: The standard RO storage tank holds from 2-4 gallons of water. A bladder inside the tank keeps water pressurized in the tank when it is full.
9. Drain line: This line runs from the outlet end of the reverse osmosis membrane housing to the drain. The drain line is used to dispose of the wastewater containing the impurities and contaminants that have been filtered out by the reverse osmosis membrane.

B. Compressors

- Air compressor is a machine which takes in air at low pressure, compresses it and delivers it to a storage tank under high pressure. From storage tank / receiver it is sent by pipeline to a place where the supply of compressed air is required.
- In the process of compression of air some work to be done on it, hence compressor must be driven by some prime mover such as electric motor, I.C. Engine or gas turbine.
- **Uses of Compressed air:**

1. It is used to operate pneumatic drills, air motors, hammers, riveting and nut tightening etc.
2. Cleaning of workshop and automobile.
3. In paint industries for spray painting.
4. In refrigeration and air conditioning industries.
5. In construction of road, dam, tunnels, bridges etc.
6. For driving mining machineries.
7. For operating air brakes.
8. In paper industries and printing machinery.
9. For conveying sand materials, concrete etc.

- **Reciprocating Compressor:**



- **Principle:** Air is compressed by reciprocation action of piston in cylinder. It provides high pressure air with intermittent discharge.
- **Construction:**

1. Crankshaft: Crankshaft is driven by prime mover such as electric motor, I.C. engine etc.
2. Crank: It is mounted on the crankshaft.
3. Connecting rod: It connects the crank and piston.
4. Piston: It is driven by connecting rod and crank.
5. Cylinder: It consist of piston which reciprocates in cylinder.
6. Inlet and Delivery valve: Inlet and Delivery valve are mounted in the head of the cylinder for suction and discharge of air respectively. These are pressure differential valves operates due to pressure difference across valve.
7. Flywheel: It is fitted on main shaft to ensure that turning moment is supplied throughout the cycle of operation.

- **Working:**

1. Suction Stroke:

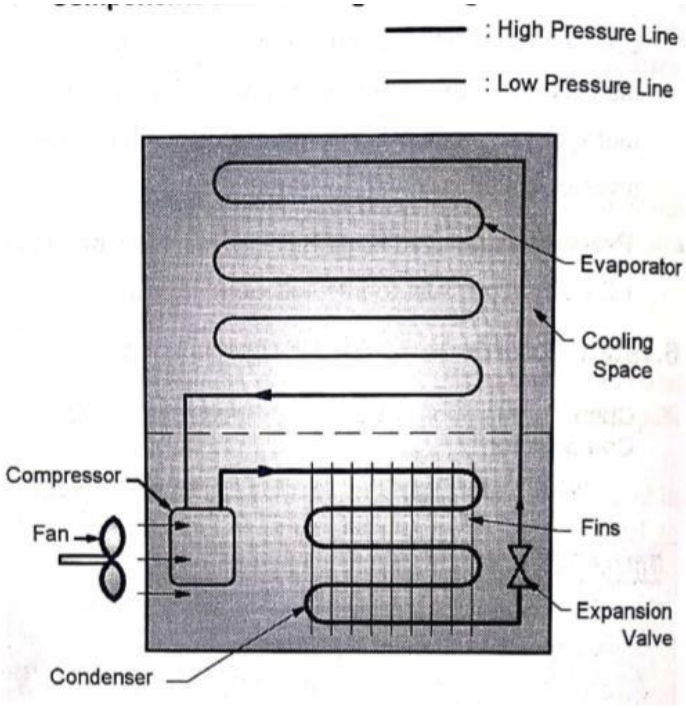
i. During suction stroke piston moves from Top Dead Centre (TDC) to Bottom Dead Centre (BDC). During downward movement of piston, the residual left in the cylinder after previous compression will expand. As air expands, the pressure inside the cylinder falls below the atmospheric pressure.
ii. The pressure outside the inlet valve is higher than the pressure inside the cylinder. Due to this pressure difference the inlet valve gets open and air is sucked into cylinder.
iii. During this stroke delivery valve remains closed because pressure inside the cylinder is less than pressure outside the cylinder.

2. Delivery Stoke:

i. After completion of suction stroke, Piston moves in upward direction. As piston moves upward, Slight increase in cylinder pressure closes inlet valve.
ii. During this stroke, both suction and delivery valves are closed hence air is compressed due to decrease in volume
iii. When the pressure inside the cylinder is slightly higher than outside pressure the delivery valve opens and compressed air is delivered from cylinder to receiver at constant pressure.
iv. At the end of compression, piston again moves down and same cycle is repeated.

1. Application of Compressor: Refrigerator

Refrigerator is an appliance having thermally insulated compartment from which the heat is removed artificially and is maintained at lower temperature for a storage of food. The capacity of refrigerator is the volume of inside storage space of the refrigerator.



- **Construction and working:**

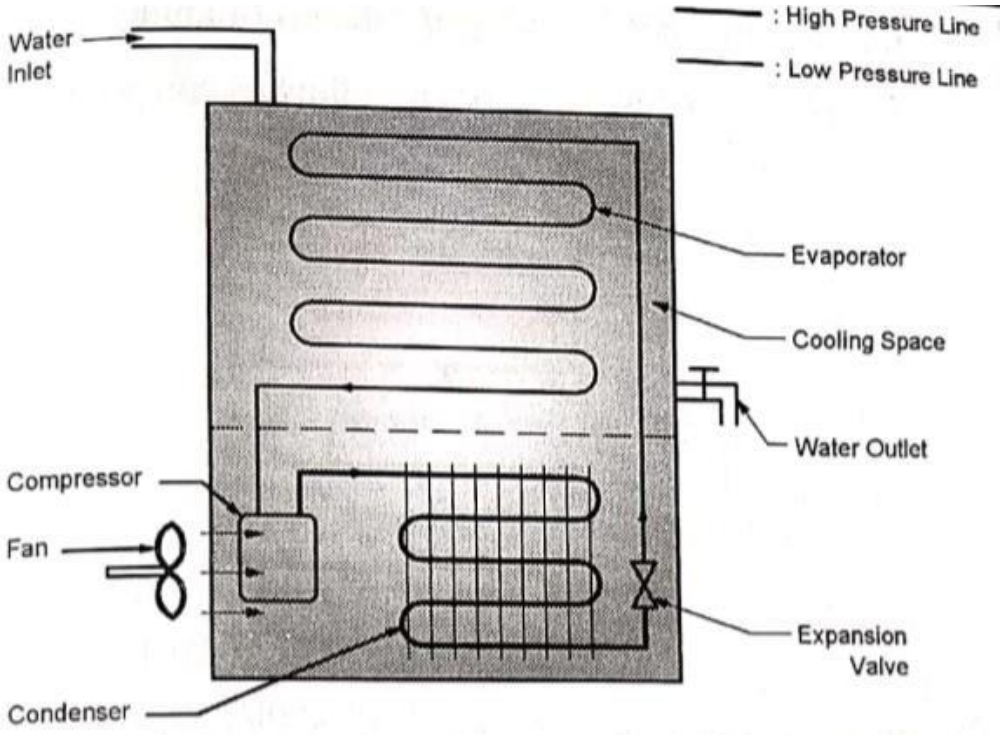
1. Evaporator: Evaporator is a coil placed around the cooling space of the refrigerator. The low temperature and low pressure refrigerant in liquid state passes through the evaporator coil. It absorbs the heat from the space to be cooled and converts the liquid refrigerant into vapour state. The heat absorption takes place at constant pressure and temperature.
2. Compressor: The low pressure and temperature refrigerant in vapour state enters the compressor. In compressor, the low pressure and low temperature refrigerant in vapour state is compressed to high pressure and temperature.
3. Condenser: The high pressure and temperature refrigerant in vapour state enters the condenser from compressor where it rejects the heat to surrounding atmosphere. The condenser coils are provided with fins for effective heat dissipation.
4. Expansion Valve: In expression valve, the expansion of refrigerant takes place. The pressure as well as temperature of refrigerant is reduced. The liquid refrigerant at low pressure and temperature again enters the evaporator.
5. Refrigerant used in Refrigerators: R134a (Tetra fluroethane)

$$\text{Coefficient of Performance} = \textbf{C.O.P.} = \frac{\text{Desired cooling effect}}{\text{Work input}}$$

$$= \frac{\textbf{Heat Removed}}{\text{Work input}} = \frac{\textbf{Qcool}}{\text{W}}$$

2. Application of Compressor: Water Cooler

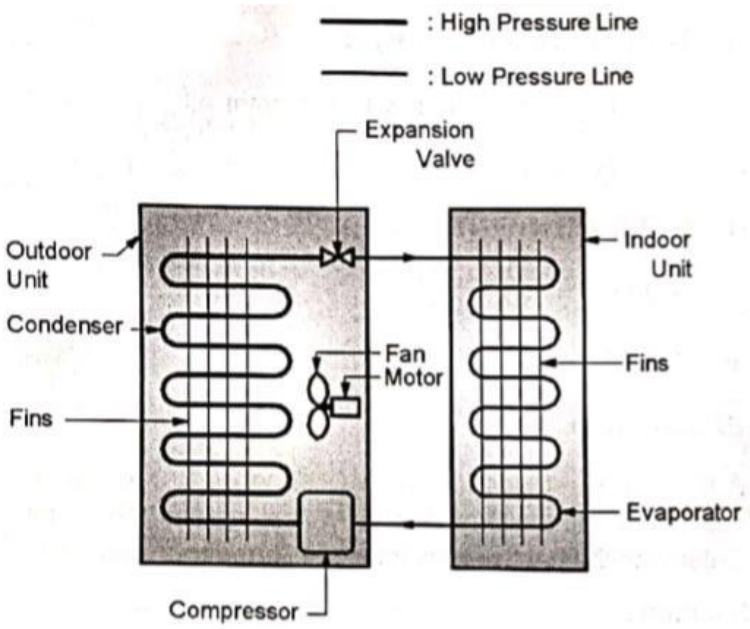
The water cooler is used for cooling the water by removing the heat using refrigeration cycle that used in refrigerator.



- **Construction and Working:**

1. Evaporator: The Evaporator is a coil placed around the cooling space of the water tank. The low temperature and low pressure refrigerator in liquid state passes through the evaporator coil. It absorbs heat from the water tank to be cooled and converts the liquid refrigerant into vapour state. The heat absorption takes place at constant pressure and temperature.
2. Compressor: The low pressure and temperature refrigerant in vapour state enters the compressor where it is compressed to high pressure and temperature.
3. Condenser: The high pressure and temperature refrigerant in vapour state enters the condenser where it rejects the heat to surrounding atmosphere. The condenser coils are provided with fins for effective heat dissipation.
4. Expansion Valve: In expansion valve, the expansion of refrigerant takes place. The pressure as well as temperature of refrigerant is reduced. The liquid refrigerant at low pressure and temperature again enters evaporator coil.
5. Water Tank: The water tank stores the cold water.

3. Application of Compressor: Split AC (Air conditioner):



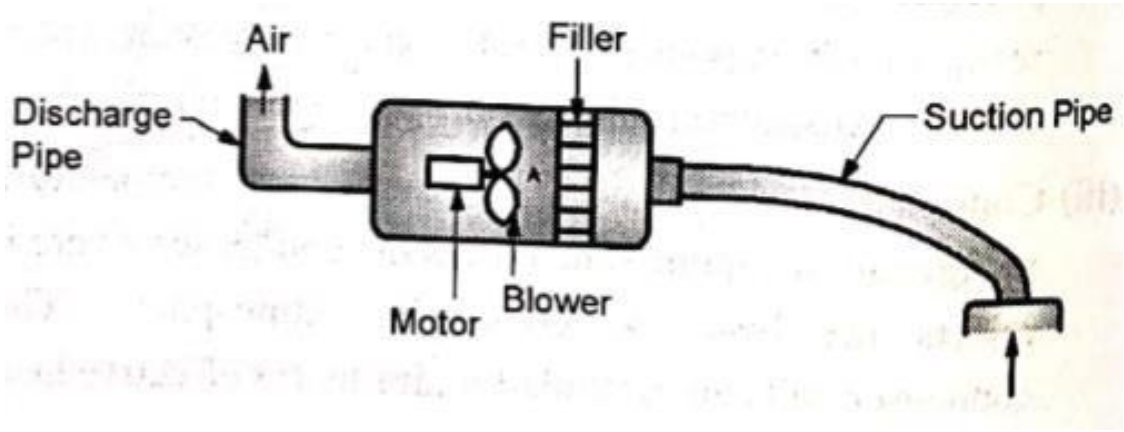
- **Principle:** Air conditioner is a system that removes heat and moisture from the enclosed space to improve the comfort of occupants. The split air conditioner is an air conditioner with two separate unit: indoor unit and outdoor unit. The indoor unit is installed inside the room to be air conditioned and outdoor unit is installed on the exterior wall or outside the room to be air conditioned.
- **Construction and Working:**

1. Evaporator: Evaporator is a coil placed inside the indoor unit. The low temperature and low pressure refrigerant in liquid state passes through the evaporator coil. It absorbs heat from the space to be cooled and converts the liquid refrigerant into vapour state. The heat absorption takes place at constant pressure and temperature. The evaporator coils are provided with fins for effective heat absorption.
2. Compressor: The low pressure and temperature refrigerant in vapour state enters the compressor where it is compressed to high pressure and temperature. The compressor is placed inside the outdoor unit of split air conditioner.
3. Condense: The high pressure and temperature refrigerant in vapour state enters the condenser where it rejects the heat to surrounding atmosphere. The condenser coils are provided with fins for effective heat dissipation. The condenser is placed inside the outdoor unit of the split air conditioner.
4. Expansion valve: In expansion valve, the expansion of refrigerant takes place. The pressure as well as temperature of refrigerant is reduced. The liquid refrigerant at low pressure and temperature again enters the evaporator coil.

C. Blower

- A blower is defined as a machine which is used to produce large volumes of gas with a moderate increase in pressure.
- It consists of a wheel with small blades on its circumference, and a casing to direct the flow of air out toward the edge. The casing in the centre of the wheel uses centrifugal force to propel the air forward into the open.
- Blowers, are mechanical devices used for circulation of air. Blower circulates air in specific given area. Blower consists of a fan, and which channels the air from the fan and directs it to a specific location or point.
- Application: Vacuum cleaner, Kitchen chimney

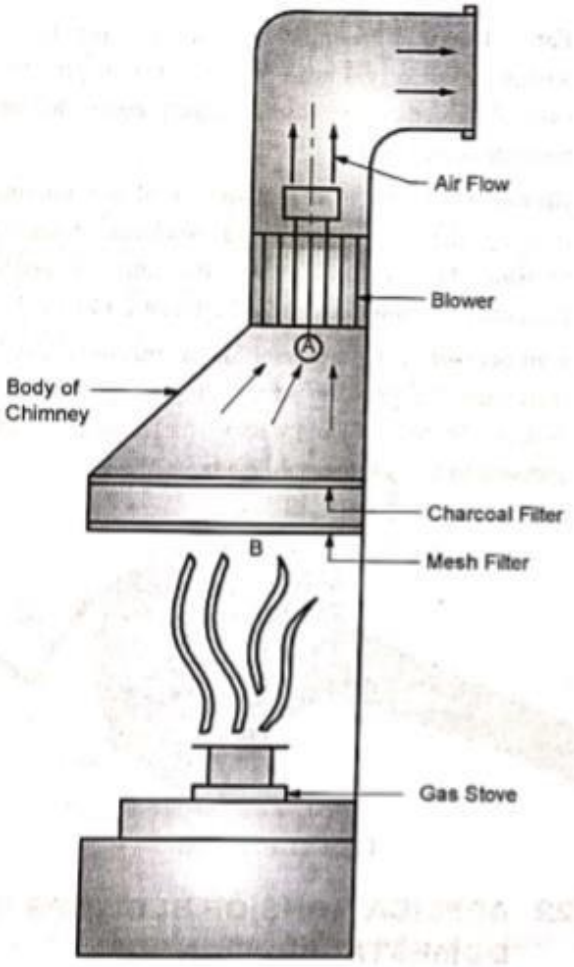
1. Application of Blower: Vacuum Cleaner



- **Principle:** Vacuum cleaner is an apparatus which collects dust and small particle form floors, other surfaces and appliances by means of suction.
- **Construction and working:**

1. Motor and Centrifugal Blower: When pressure difference is created between two locations, particles or material flows from the location of high pressure to the location of low pressure. The centrifugal blower creates vacuum (negative pressure) at point A.
2. Filter: Because of vacuum at Point A, the dust and small material particles are sucked in through the suction pipe. The filter removes the dust and small material particles and clean air is discharged to the atmosphere.
3. Suction Pipe: The dust and other small material particles are sucked through the suction pipe.
4. Discharge Pipe: The discharge pipe discharges clean air to the atmosphere.

2. Application of Blower: Kitchen Chimney:

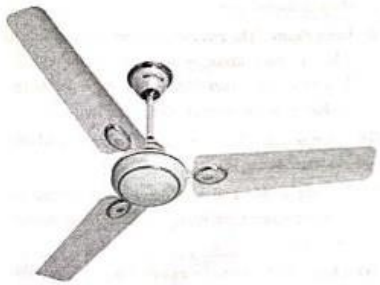


- **Principle:** When pressure difference is created between two locations, air flows from the location of high pressure to the location of lower pressure. The kitchen chimney sucks the smoke, fumes and air inside the kitchen and keeps kitchen fresh and odour free.
- **Construction and working:**

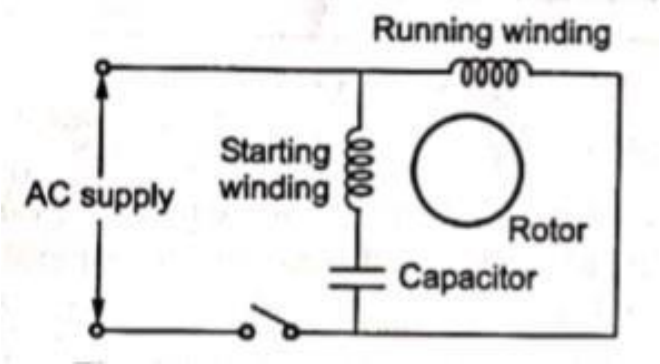
1. Blower: The blower is driven by an electric motor. The direction of blower is kept such that air flows in upward direction. It creates vacuums (negative pressure) at point A and sucks fumes and air form kitchen.
2. Mesh (Cassette) Filter: The Mesh filter has multiple layers of mesh, made of aluminium or stainless steel. It retains oil particles and smoke particles.
3. Charcoal Filter: Charcoal filter absorbs the remaining oil particles and releases relatively clean air for passing it through the chimney to the outside atmosphere.
4. Body of Chimney: The body of chimney provides passage to smoke and air from kitchen to the outside atmosphere.

D. Motor

1. Application of Motor: Fans



- A fan is an electrical device that moves air. A fan circulates the air around an entire room or a large area.
- Fan is a machine used to create a flow of air or gas. The fan has an impeller, which consists of number of blades or vanes mounted on the hub.
- The impeller or assembly of blades is driven by an electric motor. The rotating blades force the air to flow.
- The fan can produce an air flow with high volume and low pressure (higher than atmosphere pressure).
- The fans are used for air circulation in houses, offices, halls, industries, etc.
- **Motor fan:**



- **Principle:** If a current carrying conductor is placed in a magnetic field it experiences a force and start to rotate.
- **Construction:**
  i. It consists of electric motor, capacitor, blades or paddles, metal arms, flywheel, rotor, motor housing etc.
  ii. Capacitor is needed to get up enough torque to run the motor. The blades are usually made from plastic, plywood or aluminium. The metal arm holds the blade and connect it to the motors.
  iii. The flywheel is attached to the shaft of the motor.

- **Working:**

i. The capacitor of the fan torques up the electric motor which causes it to start.

ii. As soon as the electrical current reaches the motor, it enters coils of wire which are wrapped around the metal base, a magnetic field is produced that expands the force in a clockwise motion which converts the electrical energy into mechanical energy and causes the motor coil to spin.

iii. Thus, the blades attached to the motor also start gaining motion with the spinning of the coil.

iv. The rotation mechanism of the fan is such that it attract the warm air upwards and as it rises up the blades of the fan slice this air and pushes it down.

v. This being a continuous process causes the air to circulate in the entire room.

- **Applications :**

i. Water treatment aeration

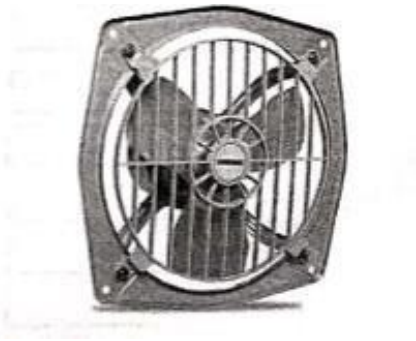
ii. Air ventilation

iii. Air drying

iv. Food processing

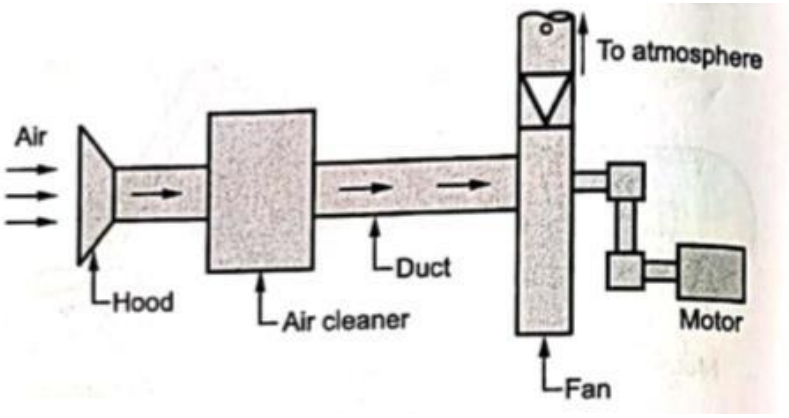
v. Construction industries

2. Application of Motor: Exhaust Fans



- Exhaust fan is a machine used for pulling air out of place like: kitchen, bathrooms, toilets, etc. It helps to drive out unwanted smoke, fumes, odour, and moisture out of the particular room or area.
- The exhaust fan has an impeller, which consists of number of blades or vanes mounted on hub. The impeller is driven by on electric motor.
- The fan creates air flow while exhaust fan pulls air out. The function of exhaust fan is exactly reverse as that of fan.

- **Exhaust Fan:**



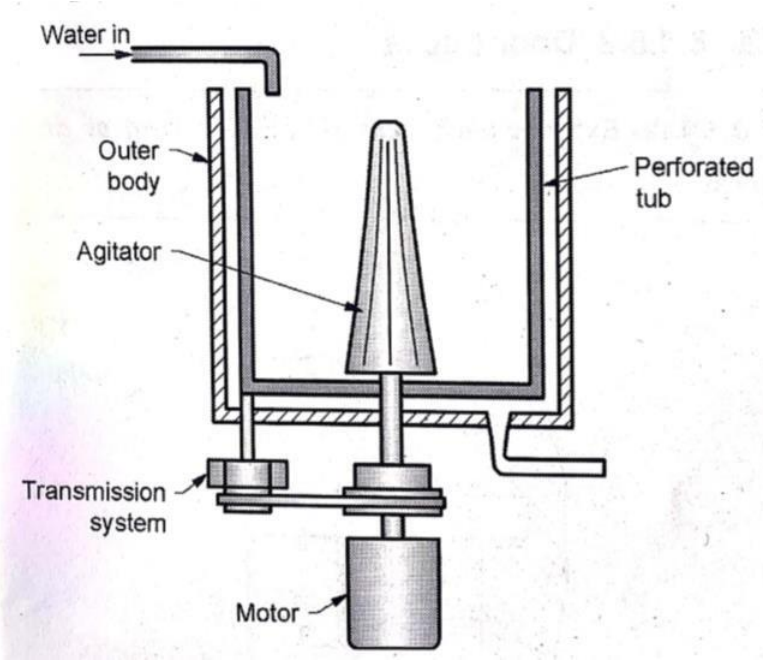
- **Principle:** It is a ventilation device which draws out the polluted air from the room and replaces it with fresh air.
- **Construction:** It consists of blades, electric motor, capacitor, rotor etc.
- **Working:**

  All exhaust fan has a rotating arrangement of blades which are driven by a motor.

  The blades take the humid air and pushes out of the room and entering the fresh air from elsewhere in the room. The effectiveness of the fan depends on the size of the room and occupants in the room. The number of blades of the fan vary from 3 to 5.
- **Applications:**

  Kitchens, Bathroom, Industries, Hospitals

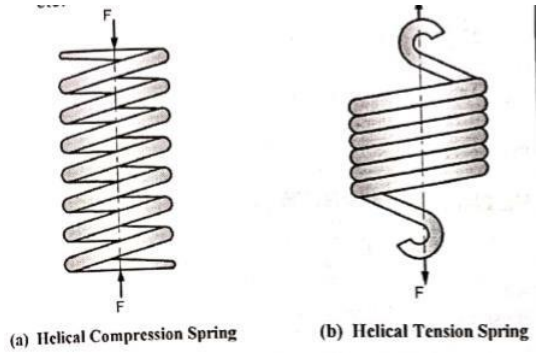
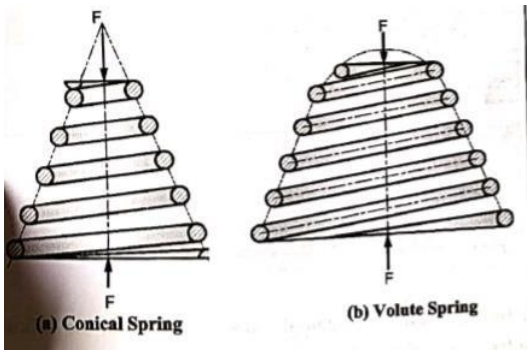
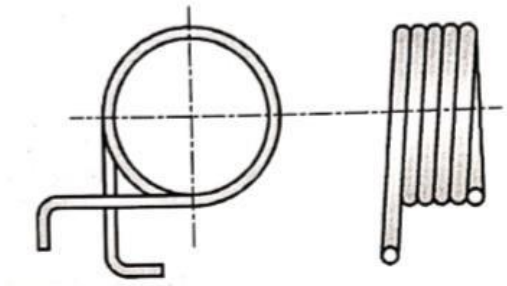
3. Application of motor: Washing Machine

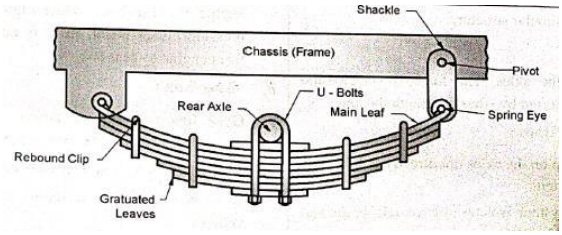


- **Principle:** It works on the principle of configuration which is the fictitious force that pulls out from the centre of the body while moving in the circular path.
- **Construction:**
  i. Water pump: It circulates the water through machine.
  ii. Water inlet control valve
  iii. Drum: The inner drum is mounted on spin tube, which is again driven by an electric motor through the belt drive. The inner drum is having holes along the surface to throw water out during the spin cycle. Outer drum is stationary and collects the water during spin cycle.
  iv. Electric motor and belt drive: The electric motor drives agitator, inner drum and water pump through the belt drive.
  v. Agitator: The large plastic agitator is mounted on agitator shaft, which is driven by an electric motor through the belt drive.
  vi. Transmission: It is gearbox mounted between belt drive and the agitator shaft.
  vii. Drain pipe
  viii. Printed circuit board
  ix. Timer
- **Working:**
  i. Washing machine is used to wash and dry the different types of cloths.
  ii. Its motor is connected with the agitator which rotates in a specific direction with specific speed with the help of transmission system.
  iii. It has a perforated tub mounted inside the main outer body, this perforated tub is also connected to the motor through transmission system, The agitator and the perforated tub both has specific direction and speed to rotate.
  iv. Sometime depending upon the type of cloth the speed of the agitator rotation also can be selected as per the wish of the operator.
  v. The whole washing process is carried out in a cycle, which is again as per the type of cloth and wish of the operator. Operator can select the different cycle option on the control panel.
  vi. Once the washing process is over the next cycle starts which is drying. In case of drying the drain pump is started and the water inside the tub is allowed to drain.
  vii. Once the whole tub is free from water then the perforated tub is rotated with high speed, because of the centrifugal force the water droplets inside the tube and the cloth gets dry as soon as cycle ends.

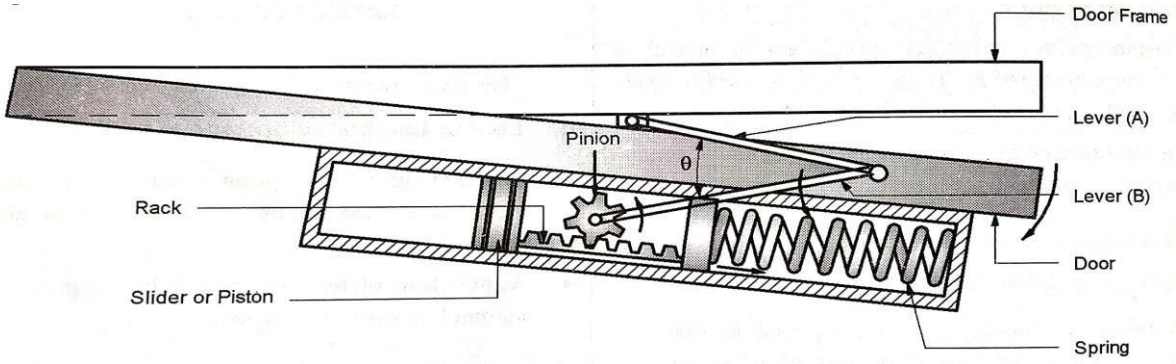
E. Springs

- **Spring:** A spring is defined as an 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**
  i. To apply a force, e.g. springs in clutches, brakes, spring loaded valves, etc.
  ii. To measure a force, e.g. spring balance.
  iii. To store an energy, e.g. springs in clocks, toys etc.
  iv. To absorb shocks and vibrations, e.g. springs in vehicle suspension systems.
- **Types of Springs:**

Sr. No.	Type of spring	Description
1	**Helical Compression and Tension Springs**  (a) Helical Compression Spring (b) Helical Tension Spring	Helical strings are made of wire wound in the form of helix. The cross-section of wire will be normally circular. Applications: Helical springs are used indoor closure, door locks, clutch, shock absorber, etc.
2	**Conical and Volute Springs**  (a) Conical Spring (b) Volute Spring	The load increases the number of active coils gradually decreases. The decreasing number of coils results in an increasing spring stiffness.
3	**Torsion Spring** 	Torsion springs are of helical or spiral type. These springs are used to apply small torque. Applications: The helical torsion springs are used indoor-hinges and automobile starters.

4	**Spiral Spring** 	The spiral springs are used in mechanical watches and clocks.
5	**Disc or Belleville Springs** 	Disc or Belleville springs are made up of number of conical discs held together by a central bolt or a pipe passing through disc hole. These springs are used where high spring stiffness is required.
6	**Leaf or Laminated Springs** 	Leaf spring consists of a number of leaves held together by means of clamps and bolts. Application: It is commonly used in automobile suspension system.

1. Application of Spring: Door Closure



- **Principle**: In door closure mechanism, the energy is applied by the person to open the door is stored in helical compression spring. When the door is released, the energy is used to utilize to bring door to its original position.
- **Construction and working:**

i. Lever A is connected to door frame whole lever B is connected to pinion of the door closure mechanism mounted on the door. The two levers are connected to each other through the pin joint.

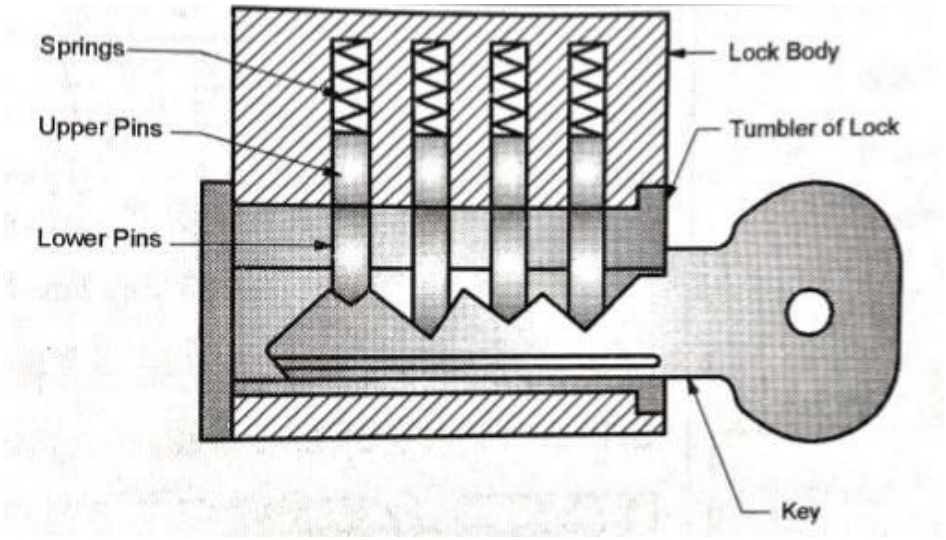
ii. When the person applies the force on the door to open the door, the angle between two levers increases.

iii. Due to this lever B rotated in anticlockwise direction. The pinion is in mesh with rack. Hence rack moves towards right side.

iv. Because of motion of rack towards right side, the helical spring get compressed and energy is stored in helical compression spring.

v. When person releases door, the spring extends and comes to its original position. The spring applies restoring force on rack and pushes rack towards left side. Because of linear motion of rack towards left side the pinion rotate in clockwise direction. The angle between two levers decreases and door is closed.

2. Application of Spring: Door Lock



i. The main components of door lock are series of lower pins of different lengths. The profile of lower side of lower pins match with the profile of the key.

ii. These are series of upper pins and helical compression springs.

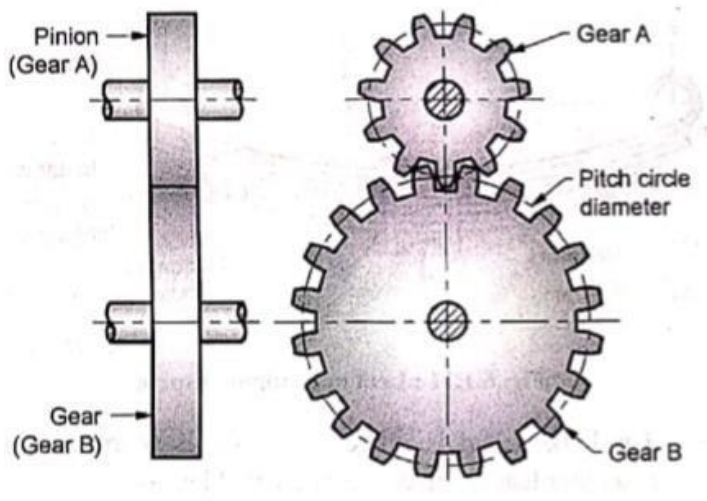
iii. The varying lengths of lower pins and profile of key give the level of security to lock.

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

v. In locked position, as correct key is not in place, the lower pins as well as upper pins are pushed downward. Hence, upper pins lock tumbler with the body of the lock.

vi. The helical compression springs exert the force on the pins and ensure that the pins can be moved up only when key is inserted.

F. Gears



- Gear drives are considered as a positive drive. The chances of slip is nil in case of gear drive. Gears are nothing but toothed wheels which are used to transmit power and motion by engagement of teeth from one shaft to other.
- The input gear on the smaller diameter gear is called as pinion and larger diameter gear or the output gear is called as wheel gear.
- Odd gears in pair rotates in same direction. Even gears in pair rotates in opposite direction.
- The gear tooth profile is either cycloid or involute.
- Gear ratio (speed ratio): It is the ratio of the speed of driving gear the speed of driven gear.
- Pitch line velocity of gears

$$\frac{\pi DANA}{60} = \frac{\pi DBNB}{60}$$

$$D_A N_A = D_B N_B$$

$$N_A / N_B = D_B / D_A$$

Where, V = pitch line velocity mm/s

D_A, d_B = pitch line diameter of gear A and B, respectively mm

N_A, N_B = speed of the gear A and B respectively, mm

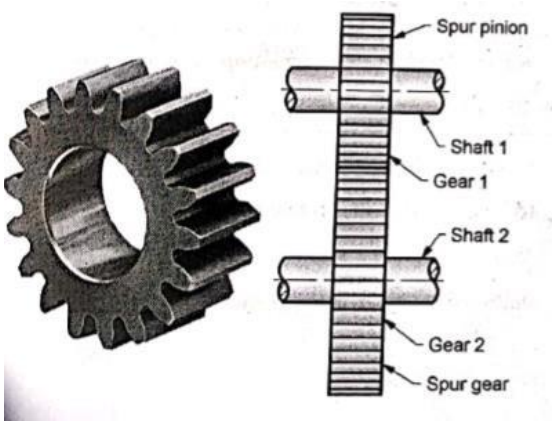
i = speed ratio or gear ratio

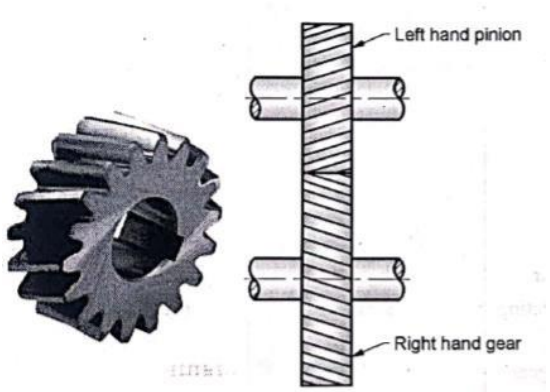
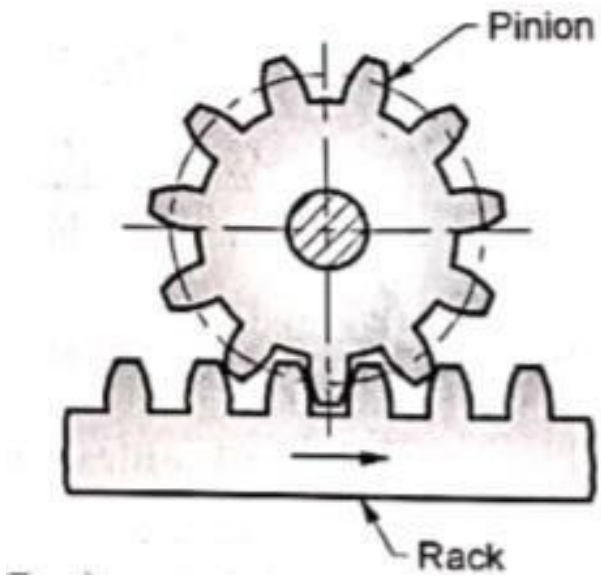
T_A, T_B = no of teeth on gear A and B respectively

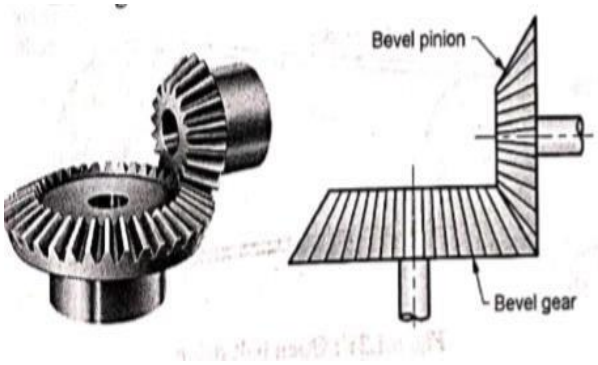
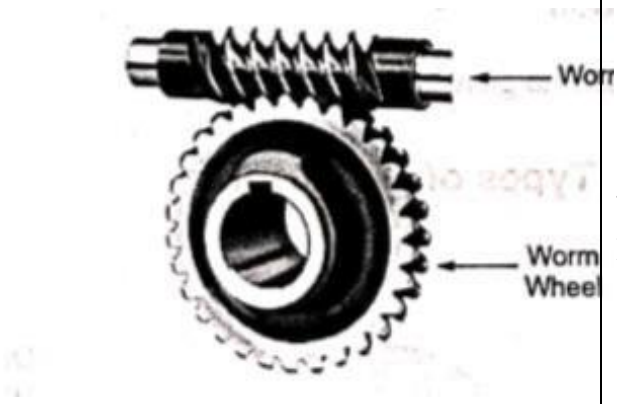
m = module, mm

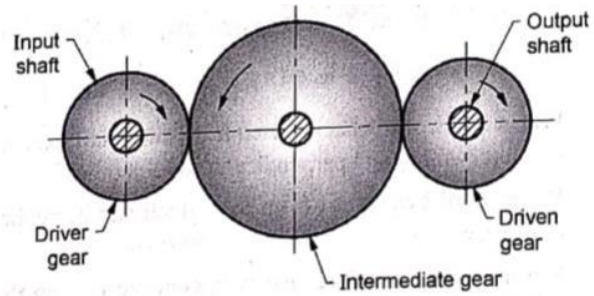
P = power transmitted

- **Advantages:**
  i. It is a positive drive hence no slip
  ii. It is compact drive.
  iii. It has high power transmitting capacity.
  iv. It can be used for variable (high to low) speed.
  v. It can be used for precision work.
  vi. Life is more.
- **Disadvantages:**
  i. Gear drives are costly.
  ii. Do not absorb shocks.
  iii. Cannot be used for long centre distances.
  iv. Requires lubrication.
  v. Requires cover or casing.
- **Types of gear:**

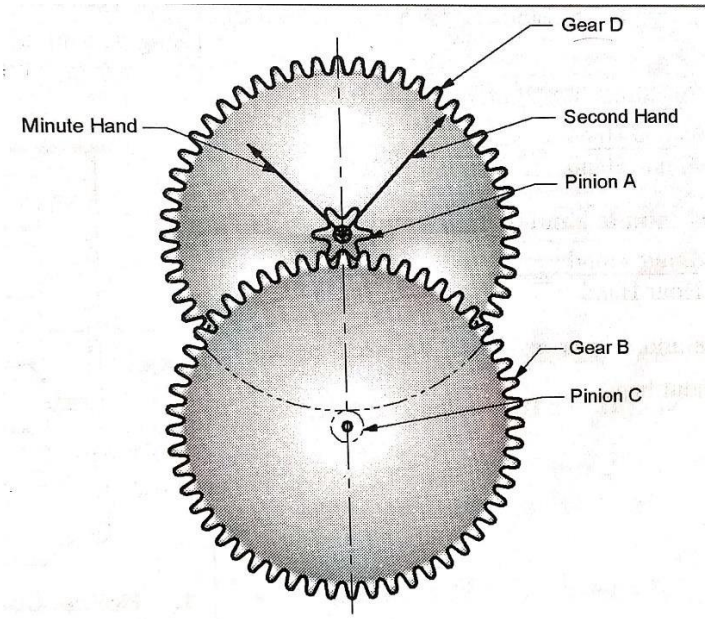
Sr. No.	Type of Gears	Description
1	**Spur Gear**  The spur gears are used where power is to be transmitted to two parallel axis shaft. The teeth axis and gear axis both are parallel to each other.	**Advantages:** 1. Spur gears are used where high power transmission efficiency is required. 2. There construction is compact. 3. There installation is easy. 4. Constant velocity ratio will be obtained. 5. No slip in case of spur gear drives. **Disadvantages:** **1.** Spur gear is noisy in operation. **2.** Spur gears are not suitable for long distance power transmission. **3.** Stress observed in Spur Gears is more. **Applications:** Sugar cane juice centre, Metal cutting machines, Fuel pumps, Gear motors and gear pumps, Rolling mills

2	**Helical Gear**  The teeth axis and gear axis are at certain angle. This angle is known as helix angle. In gear pair of helical gear the helix angle are of same magnitude but of opposite hands.	**Advantages:** 1. Produce less noise while in operation. 2. Helical gears are best .suitable for heavy load applications. 3. Less wear and tear 4. Operations performed are smooth. **Disadvantages:** 1. Its manufacturing cost is high compared with spur gears. 2. Axial thrust load occures. 3. It gives less efficiency as compared with spur gears. 4. Power loss is more as compared with spur gears. **Applications:** Vehicle gear box, Printing industries, Textile industries
3	**Rack and pinion**  It is used when rotational motion is need to be converted into linear one. Rack is gear having straight line gear. It is also called also a gear with infinite pitch circle.	**Advantages:** 1. Best suitable for converting rotary motion into linear motion. 2. Construction of Rack and pinion is compact. **Disadvantages:** l. Energy is loosed in overcoming the friction. 2. Rack and pinion has more Wear and tear. 3. Replacement of rack and pinion is to be done after certain use. **Application:** Steering System, used where rotary motion needs to be converted into linear motion

4	**Bevel Gears**  Bevel gears are used when two axis of the shafts are intersecting to each other. Bevel gears are used to turn the drive by 90°.	**Advantages:** 1. Bevel gears operational angle can be changed as per the need. 2. Bevel gears efficiency is quite enough which is up to 90% 3. Bevel gears have low sliding friction. 4. Bevel gears manufacturing cost is less. **Disadvantage:** 1. Bevel gears assembly needs to be done precisely. 2. Bevel gears produce noise at high speed. 3. Bevel gears are not suitable for high speed reduction. **Applications:** 1. Bevel gears are used in differential drives. 2. Bevel gears are used where power needs to be transmitted at right angles. 3. Bevel gears are used in hand drill mechanism.
5	**Worm and Worm Wheel**  Worm and worm wheel is used if the two shaft axis are nonintersecting and perpendicular to each other. Worm gear is a helical gear with concave face so that worm periphery can be meshed easily.	**Advantages:** 1. They are self-locking gear pair 2. High velocity ratio 3. Occupy less space 4. They have effective meshing. **Disadvantages:** 1. Worm and Worm Wheel have high power loss. 2. They have low transmission efficiency. 3. Heat generation is more **Applications:** Steering mechanism of the Automobile vehicles, Wind mills, Conveyors

6	**Simple gear train** 	In a simple gear train each shaft carries one wheel only and there is no relative motion between axes of the shaft of the gear. If odd number of gear are there the input and output gear will rotate in same direction while even number gears it rotates in opposite for directions.

1. Application of Gear: Wall clock/ Watches



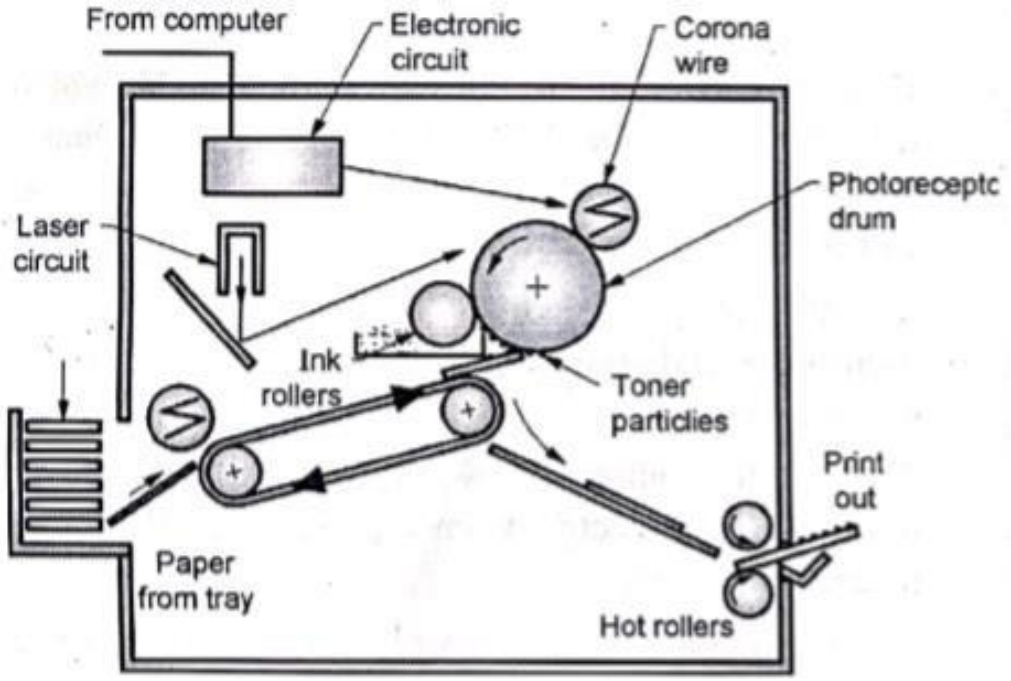
- Fig. shows mechanism of gear in wall clock. The pinion A is in mesh with gear B. the pinion C is rigidly connected to gear B. the pinion C is in mesh with gear D.
- The second hand is connected to pinion A while the minute hand is connected to gear D.
- Let Z_A, Z_B, Z_C, Z_D= number of teeth on Pinion A, gear B, Pinion C and gear D respectively.
  N_A, N_B, N_C, N_D is speed of pinion A, gear B, Pinion C and gear D respectively.
  As gear B and pinion C are rigidly connected, $N_B = N_C$,
- Speed ratio of second hand to minute hand,

$$\frac{\text{Speed of second hand}}{\text{Speed of minute hand}} = \frac{NA}{ND} = \frac{NA \times NB}{NB \times ND}$$

$$= \frac{NA \times NC}{NB \times ND} = \frac{ZB \times ZD}{ZA \times ZC}$$

- In clock electric stepping motor is used to turn the gears.
- In this way electric energy is converted into mechanical energy.

2. Application of Gear: Printer



i. When we print something, computer-sends vast electronic, data stream to the printer.

ii. Electronic circuit in the printer receives the signal from the computer and analyses it so that this data will look correct on the printout page.

iii. Electronic circuit activates corona wire. It is high voltage wire which charges nearly area with static electric charge. Photoreceptor drum is charged by corona wire so drum gains a positive charge. Simultaneously circuit activates the laser to draw an image of the page on the drum. Slowly the image of the entire page is built on the drum.

iv. There are some areas which are charged negatively where the page should be black and there are some areas which are positively charged where the page should be white.

v. Ink roller is touching the photoreceptor drum which coats it with tiny partials of the toner powdered ink.

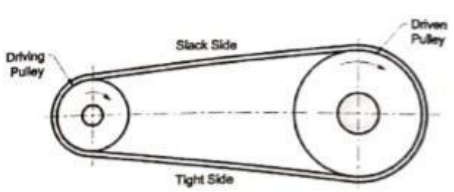
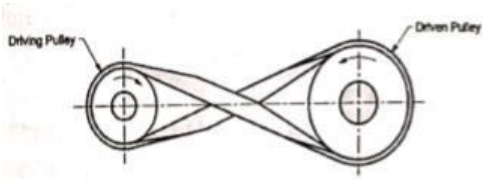
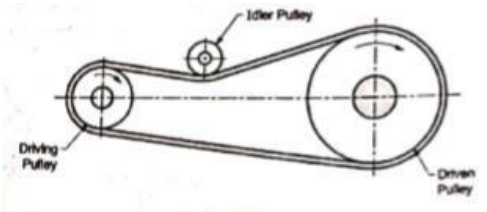
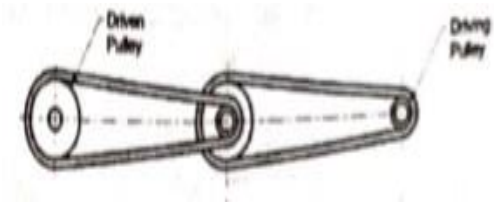
vi. As we know opposite electrical charges attracts on the same line toner has given a positive electrical charge so it sticks to the parts of the photoreceptor drum which is negatively charged on the positively charged area no ink is attracted. An image full of ink is built on the drum.

vii. Paper from the tray is feed towards the drum as it moving it is strongly charged positively by another corona wire. At time when paper moves area near the drum its positive charge attracts toner particles from the drum which are negatively charge.

viii. This image is transferred from the drum on the paper page is passed through two hot rollers so that because of heat and pressure from the rollers fuses the toner particles permanently on the paper. So paper fills like warm after it settles down in the tray.

G. Belt drive

- **Types of belt drive:**

Sr. No.	Type of belt drive	Description
1	**Open belt drive:** 	In open belt drive, both the pulleys rotate in same direction **Use:** The open belt drive is used when the shafts are parallel
2	**Cross belt drive:** 	Both the pulleys rotate in opposite direction. Cross belt drive gives stronger friction grip compared to open belt drive. At a point where the belt crosses, it rubs against each other so there will be excessive wear and tear. **Use:** The crossed belt drive is used when the shafts are parallel and centre distance is shorter.
3	**Open belt drive with idler pulley:** 	The open belt drive with an idler pulley is used to obtain the high velocity ratio and the desired belt tension. **Use:** The open belt drive with an idler pulley is used when the shafts are parallel and when an open belt drive cannot be used
4	**Compound belt drive:** 	A compound belt drive gives relatively high reduction ratio. **Use:** A compound belt drive is used when the power is to be transmitted from one shaft to another through a number of intermediate pulleys.

- **Advantages of Belt Drives:**
  i. Flat belts can be used for long centre distances.
  ii. Belts are flexible, and hence, can absorb shocks and vibrations.
  iii. Belt drives are relatively cheap and easy to maintain.
  iv. Belt drives do not require lubrication.

v. Belt drives run with less noise.

vi. Belt drives are not affected by dirt or dust, and hence, can operate in an open atmosphere without cover.

- **Limitations of Belt Drives:**

i. Belt drive is not a positive drive, and hence, there is some amount of slip.

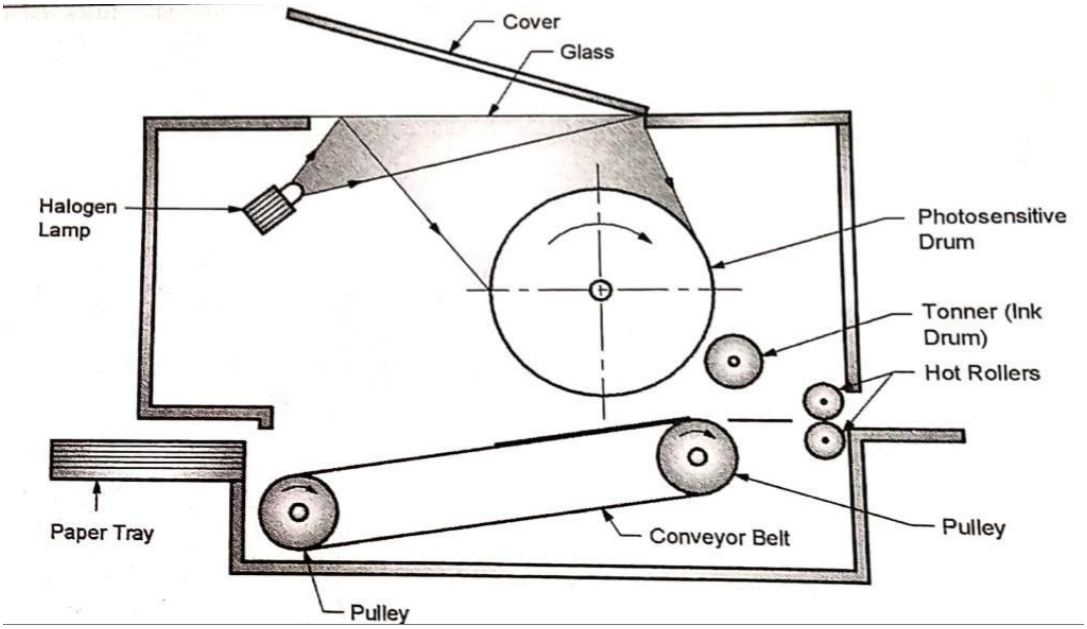
ii. Belt drives occupy more space as compared to gear drives.

iii. Belt drives have a relatively short life as compared to gear drives.

iv. Belt drives cannot be used at extremely high speeds because of effect of centrifugal force on belts.

v. Flat belts have low power transmitting capacity.

1. Application of Photocopier



- **Construction:**

i. Halogen lamp: It scans the document.

ii. Photosensitive drum: It carries shadow of document towards toner.

iii. Toner (ink drum): Toner contains ink.

iv. Conveyor belt and pulley: Paper from tray is carried towards photosensitive drum by conveyor belt.

v. Hot rollers: It fuses toner permanently on paper.

- **Working of Photocopier:**

i. In photocopier machine, conveyor belt is used for carrying the paper from paper tray to the hot rollers.

ii. When document is placed on glass, beam of halogen light scans the document. The light gets reflected and electrical shadow of document (negatively charged image) is formed on photosensitive drum.

iii. As photosensitive drum rotates, it carries electrical shadow of document (negatively charged image) towards toner.

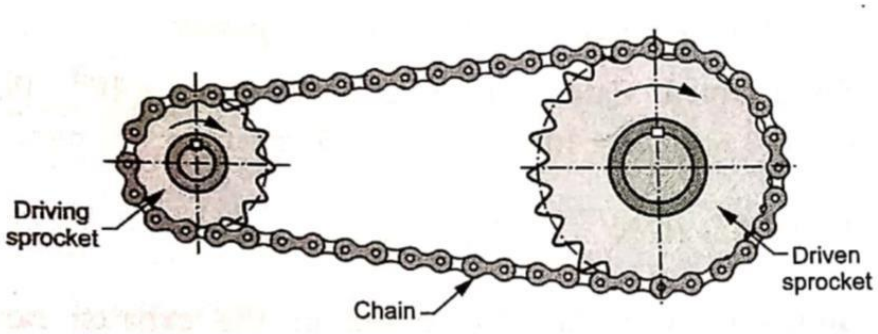
iv. The toner is positively charged. The positively charged toner ink sticks to negatively charged image on the drum surface.

v. Thus, inked image of document is formed on the surface of the drum.

vi. The paper is carried by the conveyor belt from paper tray. The paper is given electric charge. Therefore, inked image from the surface of the drum is transferred to the paper on conveyer belt.

vii. When paper passes through two hot rollers, heat and pressure from rollers permanently fuses the tonner particles on the paper.

H. Chain drive



i. A chain drive consists of an endless chain runs two sprockets. Sprockets are nothing but wheels with tooth of special profile.

ii. A chain consists of two rows of inner plates and outer plates which are connected together with the help of pin and bush.

iii. The chain drive is semi positive drive which shows features of belt drive as well as gear drive.

iv. The chain wraps the sprocket in the form of polygon.

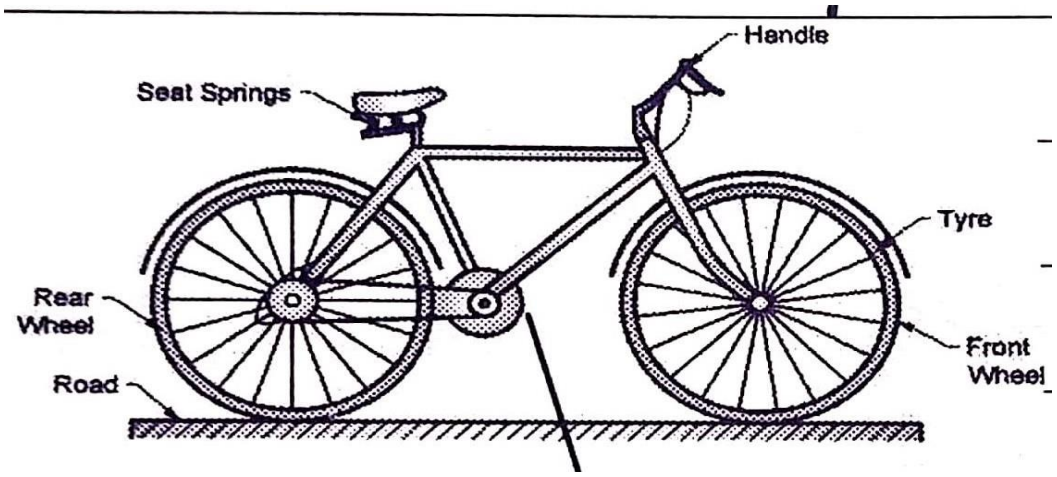
v. The links of chain form sides of polygon because of this output speed at the output sprocket is not constant even through the input speed at input sprocket is constant. This kind of effect is called as polygonal effect.

vi. The chain drive is commonly used to transmit motion from one shaft to other shaft for a short centre distance.

vii. For effective functioning of chain drive lubrications are required.

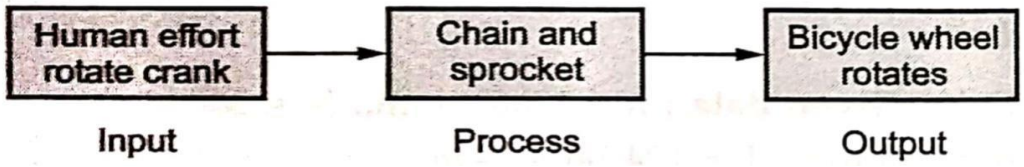
- **Advantages:**
  i. The chances of slip is less as compared with the belt drives.
  ii. In case of any centre distract between two shafts chain drive can be used.
  iii. Compact as compared with belt drives.
  iv. Can be used if there is any misalignment between shafts.
  v. It gives high efficiency up to 98%.
  vi. Less expensive than gear drive.
- **Disadvantages:**
  i. Not suitable when precision is expected.
  ii. It need proper lubrication time to time and slack length need to be adjusted.
  iii. They create noise during operation.
- **Applications:**
  Bicycles, motor cycles, conveyors, road rollers, rolling mill, agricultural machinery, etc.

- **Application of Chain drive: Bicycle**



- **Principle:** Transferring of power from the pedals to drive wheel of a bicycle.
- **Construction:** The basic parts of the bicycle are:
  i. Frame
  ii. Steering
  iii. Seating
  iv. Brakes
  v. Chain and sprocket
  vi. Wheels and tires
  vii. Suspension

- **Working:**
  i. Chain and sprockets are used for transmitting force from the output drive shaft to another shaft.
  ii. A sprocket is a toothed wheel that is used to transmit the motion from one shaft to another and chains are used to transmit force from one sprocket to another.
  iii. In case of bicycle the human effort will rotate the crank through which power is transmitted to the chain and sprocket arrangement which drive the wheels of the bicycle.



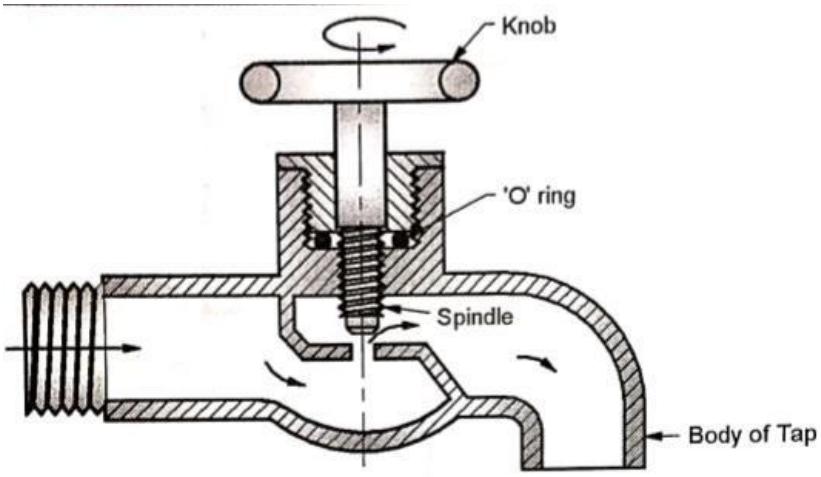
- **Comparison between Belt drive, Chain drive and Gear drive:**

Sr. No.	Parameter	Belt drive	Chain drive	Gear drive
1	Elements of drive	Non Positive	Positive	Positive
2	Used for	Driving pulley, Driven pulley , belt	Driving sprocket, Driven sprocket, belt	Gear and Pinion
3	Power transmitting capacity	Moderate to low	Moderate	High
4	Lubrication	Not required	Periodically required	Continuously required
5	Space requirement	More	Medium	Low
6	Relative position of axes of two shaft	Parallel	Parallel	Parallel, perpendicular, intersecting
7	Ability to absorb shock	Flexible. Can absorb shock.	Can absorb shock.	Can not absorb shock.
8	Suitability to high speed	Not suitable	Not suitable	Suitable
9	Cost	Low	Medium	High

I. Valves

- Valve is device for controlling the flow of fluids (liquids, gases, slurries, etc.) in a pipe or other enclosure.
- Control is by means of a movable element that opens, shuts or partially obstructs an opening in a passageway.
- **Applications :**
  i. Controlling water for irrigation.
  ii. Residential uses like ON/OFF and pressure control to dish and clothes washers and taps in the homes.
  iii. Industrial uses for controlling the process.
  iv. Military and transport sectors.
  v. In veins for controlling blood circulation etc.

1. Application of Valve: Water Tap



- **Principle:** The principle of the valve is to regulate, direct and control the flow of a fluid by opening and closing the water tap.
- **Working:**
  i. Water tap is used to start, stop or control the flow of water.
  ii. When knob is rotated, the spindle moves up and down. The upward movement of spindle opens the passage of water flow while downward movement of spindle closes the passage of water flow.
  iii. The part of tap that we turn is only top portion of the screw which is in mesh with tap body, this screw travels up and down once the handle is rotated.

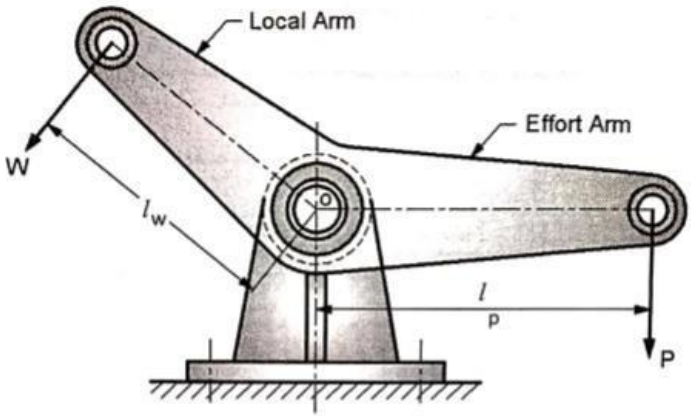
iv. A rubber washer is attached on the bottom of the screw. It is placed on seat of the tap so that, it will stop water flow out. When we rotate the handle, the screw rises which lifts washer from the seat. As the seat gets lifted up water comes out of the tap.

v. When again we turn rotate handle to off the water flow. The screw gets lowered and washer gets placed on the seat, hence water stores from coming out.

vi. In case of the leakage there is the need of placing the washer correctly if still the leakage continues then washer needs to be replaced.

J. Lever

- Lever: Lever is a rigid rod or bar pivoted at a point called fulcrum.
- Use:
  i. To overcome load by application of small effort.
  ii. To facilitate application of effort in desired direction.
- **Effort arm and load arm:** In a lever, a perpendicular distances of the effort and load from the fulcrum are known as effort arm and load arm respectively.
- **Leverage:** The ratio of the effort arm to the load arm is called leverage.
- **Mechanical advantage:** The ratio of load to the effort is called mechanical advantage.



In fig; W = load to be overcome, N

P= effort applied, N

f = load arm, mm

l_p = effort arm, mm

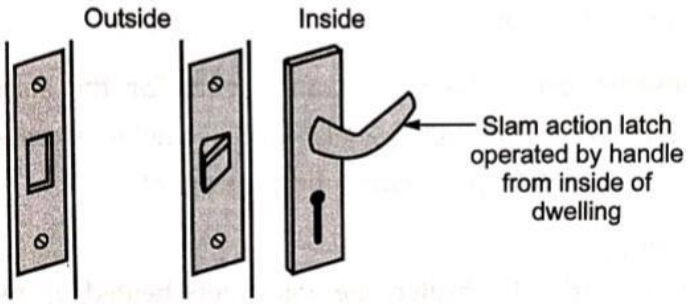
By taking the moment about the fulcrum,

$W l_w = P l_p$

$W / P = l_p / l_w$

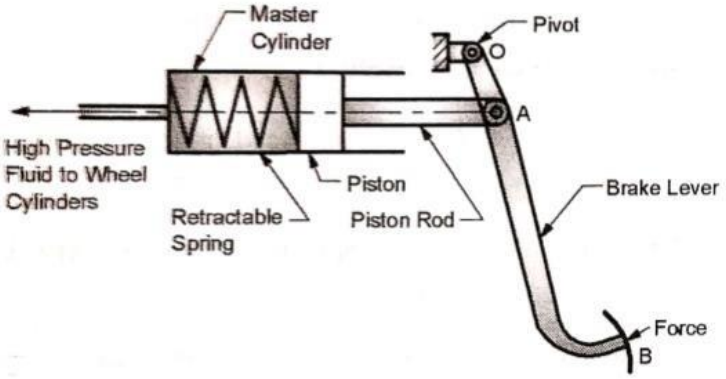
Mechanical advantage = Load/effort =W/ P = leverage

1. Application of lever: Door Latch



i. The traditional door knob has a bolt or spindle running through it that sits just above a cylinder, to which the spindle is connected.
ii. The most common and basic type of doors handle is the Lever latch door handle on a back plate found in residential houses and commercial and public buildings.
iii. Doors fitted with this handle have a latch that keeps the door shut. The door handle has only a lever handle which operates this latch.
iv. Pushing the handle down rotates the spindle, operating the tubular latch mechanism inside the door, allowing it to be opened.
v. This type of door handle is used on interior doors that do not require to be locked. The lever latch handle is easy to install and use, and is available in a variety of styles and finishes.

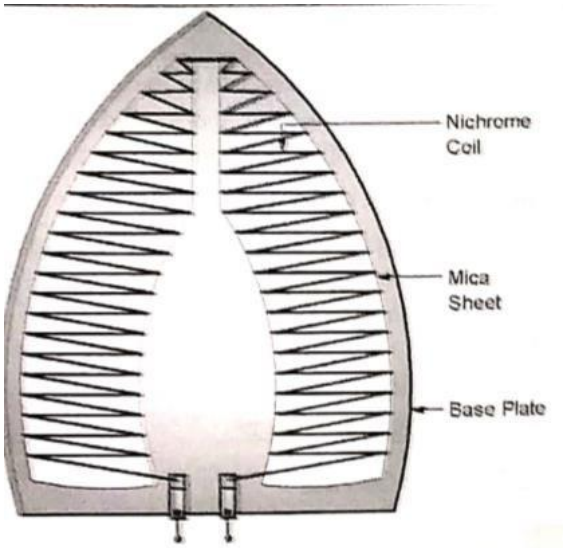
2. Brake pedal:



i. The brake lever (pedal) is used for applying the brake in vehicles.
ii. The brake lever (pedal) is pivoted at point O. It is connected to piston rod at point A and braking force is applied at point B.
iii. When braking force is applied at point B, the piston rod pushes the piston and increases the pressure of brake fluid in master cylinder.
iv. The high pressure brake fluid is supplied to all wheel cylinders for braking action.
v. When brake is released, the retractable spring helps to bring the piston and brake lever to original position.

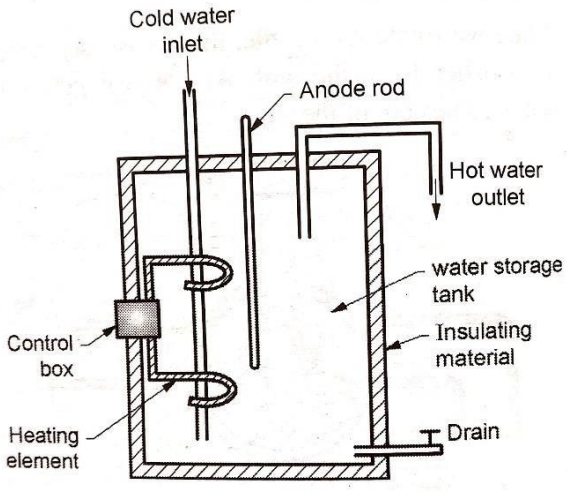
K. Electric and Solar energy application

1. Electric Iron



- **Working Principle:**
  i. When electric current is passed through the coil, it gets heated.
  Heat generated by coil: $H = I^2Rt=VIt$
  Where, H = heat generated, J
  I= electric current flowing through the coil, A
  R=resistance of coil, ohm
  V = supply voltage, V
  t = time, Sec
  ii. Functioning of electric iron is based on the heat and pressure.
- **Components of electric iron:**
  i. Nichrome coil: In electric iron, the Nichrome coil is used as a heating element. It has relatively high resistance. Therefore, when current is passed through the Nichrome coil, it produces high heat.
  ii. Mica Sheets: The Nichrome coil is placed between two mica sheets. The Mica is an electric insulator but a good conductor of heat.
  iii. Steel Base Plate and Body: When an electric current is passed through the heating coil (Nichrome coil); the coil gets heated. The heat is transferred to base plate due to conduction. The heat of base plates and manual pressure applied on iron, helps to iron the clothes.

2. Electric geyser:



- **Principle of Electric Geyser:** In electric geyser, the current is passed through the heating coil. The coil gets heated. The heat of coil is used for raising the temperature of water through conduction. Heat generated by coil: $H = I^2Rt=VIt$

  Where, H = heat generated, J

  I= electric current flowing through the coil, A

  R=resistance of coil, ohm

  V = supply voltage, V

  t = time, Sec

  Heat supplied to water: $H = mC_p\Delta T$

  Where, H = heat supplied to water, J

  m = mass of water, kg

  C_p = specific heat of water, J/kg°C

  ΔT = temperature rise of water, °C

- **Component and Working of Electric Geyser:**
- The electric geyser consists of following components:

i. Insulating Container: The container is provided with insulating layer so as to avoid the dissipation of heat to surrounding atmosphere.

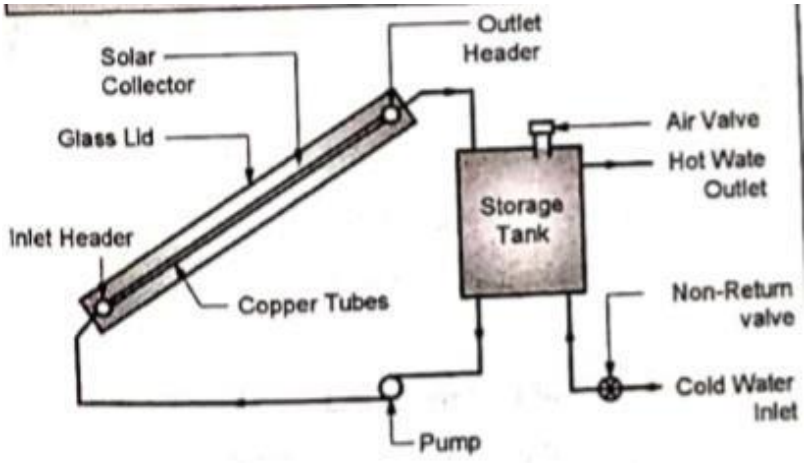
ii. Cold Water Inlet: The cold water is supplied to the geyser through cold water inlet pipe. The cold water inlet pipe is provided with inlet valve so as to control the supply of cold water.

iii. Hot water Outlet: The hot water is taken out from the geyser through the hot water outlet. The hot water is light, and hence, it is in the upper part of tank.

iv. Heating Element: Heating element is used to heat the water. It is operated by control box.

v. Air Valve: It acts as safety valve. If the pressure inside the geyser shoots up because of some reason, the valve opens and releases the high pressure fluid to ensure the safety.

3. Solar water heater:



- **Principle**: Solar water heater is used to heat water by using solar energy which is renewable, non-polluting and available free of cost in abundance.
- **Components and Working of Solar Water Heater:**

  The solar water heater consists of following components

  i. Storage Tank: The cold water is supplied to the storage tank form inlet pipe. The non-return valve fitted on the inlet pipe prevents the reverse flow of water from storage tank to the inlet pipe.

  ii. Pump: The supply tank supplying the water to storage tank should be at sufficient height. If there is no sufficient gravity head, the pump is used to supply the water to the solar collector from storage tank.

  iii. Solar Collector: The solar collector consists of an insulated box covered with glass lid. The insulated box contains number of copper tubes, connected between inlet header and outlet header.

  The copper tubes are painted by black colour form outside. The cold water enters the inlet header and flow through the copper tubes. The solar radiation heats the water flowing through the copper tubes (copper is a good conductor of heat).

  The black colour is a good absorber of heat. The glass lid prevents the loss of heat due to radiation. The solar collector is inclined so that as water gets heated, it moves up. The hot water form outlet header flows to the storage tank.

- **Note:**
  1. **Refer Numerical on efficiency calculation of pump and compressor from unit 1.**
  2. **Refer Numerical on COP of refrigerator from unit 2.**