Unit 6: Engineering Mechanics and their Application in Domestic Appliances

University Prescribed Syllabus

Introduction to Basic mechanisms and equipment: Pumps, blowers, compressors, springs, gears, Belt-Pulley, Chain-Sprocket, valves, levers, etc. Introduction to terms: Specifications, Input, output, efficiency, etc.

Applications of : Compressors : Refrigerator, Water cooler, Split AC unit; Pumps - Water pump for overhead tanks, Water filter/Purifier units; Blower - Vacuum cleaner, Kitchen Chimney; Motor - Fans, Exhaust fans, Washing machines; Springs - Door closure, door locks, etc.; Gears - Wall clocks, watches, Printers, etc.; Application of Belt-Pulley/Chain-Sprocket - Photocopier, bicycle, etc.; Valves - Water tap, etc.; Application of levers - Door latch, Brake pedals, etc.; Electric/Solar energy - Geyser, Water heater, Electric iron, etc. (simple numerical on efficiency calculation)

6.1 INTRODUCTION

Mechanism is the term used to describe a system in which stiff bodies are joined together to transmit force and/or motion as required.

Machine is a device used to perform desired work. It may include various mechanisms. Mechanism usually composed of moving members which includes:

a. Belt & Pulley
b. Chain & Sprocket
c. Gear drive
d. Spring, Levers etc

In this unit, we will explore numerous mechanisms and how they work in household appliances.

6.2 INPUT, OUTPUT & EFIICIENCY

6.2.1 Input:

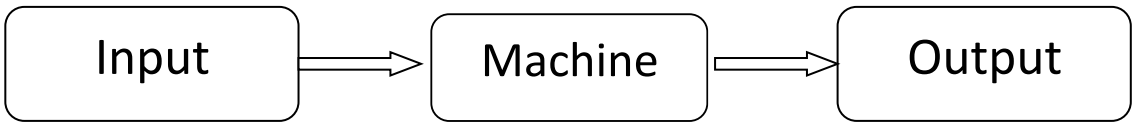
Work input is work performed on a machine to get the desired output. Any motion or force that propels the mechanical system is the system's input.

6.2.2 Machine:

A device consists of some stationary and some moving parts that are designed to do a particular job.It is an innovation or instrument that increases the impact of human effort.

6.2.3 Output:

Work output is the total quantity of intended work completed by a machine.The degree, to which a machine is able to transform its input energy into useable output energy, or work, is referred to as its efficiency.



Example: In drilling machine, Electrical energy (Input) is applied to drill machine which converts into mechanical energy (Output- Rotation of spindle) to drill a hole.

6.2.4 Efficiency:

Efficiency is the proportion of work done by a machine throughout a process to the overall amount of energy used.

For a machine, you can determine the work put into the machine depending on how the machine works.

Efficiency = Output / Input is the formula for calculating work efficiency, and you can multiply the result by 100 to obtain work efficiency as a percentage.

6.3 PUMP

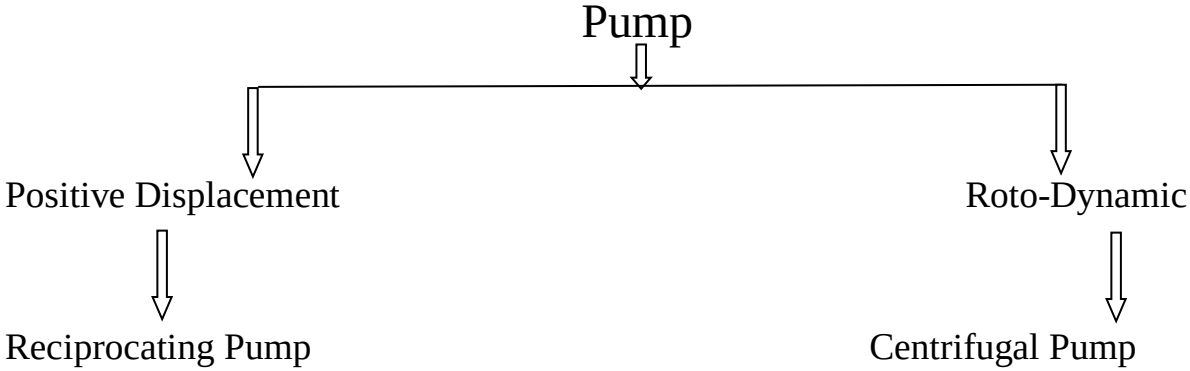
Definition:

Pump is a mechanical device that transfers the mechanical energy it receives into hydraulic energy.

Additionally, they are utilized to generate pressure by creating a suction (partial vacuum), which propels the fluid upward to a greater height.

Pumps are used to elevate the water's energy level, allowing it to be raised to a desired height.

6.4 CLASSIFICATION OF PUMP



6.5 POSITIVE DISPLACEMENT PUMP

A positive displacement pump mechanically transports a fluid through a system by continually enclosing a specific volume.

Pistons, screws, Vanes, Gears, or vanes can all be used to power the cyclical pumping motion.

Ex: Reciprocating Pump

6.6 ROTO-DYNAMIC PUMP

Roto-dynamic pumps, also known as dynamic pumps, are a category of velocity pump in which the fluid is given kinetic energy by speeding up the flow.

In this instance, the speed of the impeller and the amount of vacuum necessary to generate flow are dependent on the rotation of the shaft.

Ex: Centrifugal Pump

6.7 APPLICATION OF PUMP

1. To transfer water from a source to fields for irrigation and farming purposes.
2. To pump oil in petroleum systems.
3. To circulate feed and cooling water in power plants.
4. For the drainage system, sewage treatment, and water supply in communities.
5. To move chemical liquid between two locations.
6. Water pumping inside structures and for combating fires.
7. To power hydraulic equipment like lifts and cranes.

6.8CENTRIFUGAL PUMP

A centrifugal pump is a hydraulic device that converts mechanical energy into hydraulic energy by using the centrifugal force acting on the working fluid.

Due to the dynamic pressure that is created to elevate the liquid from one level to another, centrifugal pumps are also known as rotodynamic pumps.

6.8.1 Working Principle:

- The basis of centrifugal pumps is the idea that when a certain amount of fluid is induced to revolve along the impeller around the central axis of rotation, a centrifugal force is imparted, causing the liquid to travel quickly in outward direction.
- It converts this velocity head into a pressure head.
- ‘Force vortex flow’ is the fundamental operating concept of centrifugal pumps.
- This indicates that when a certain amount of fluid is rotated, its pressure increases.
- The velocity of the liquid has a direct relationship with this rise in pressure.

6.8.2 Main Components of Centrifugal Pump:

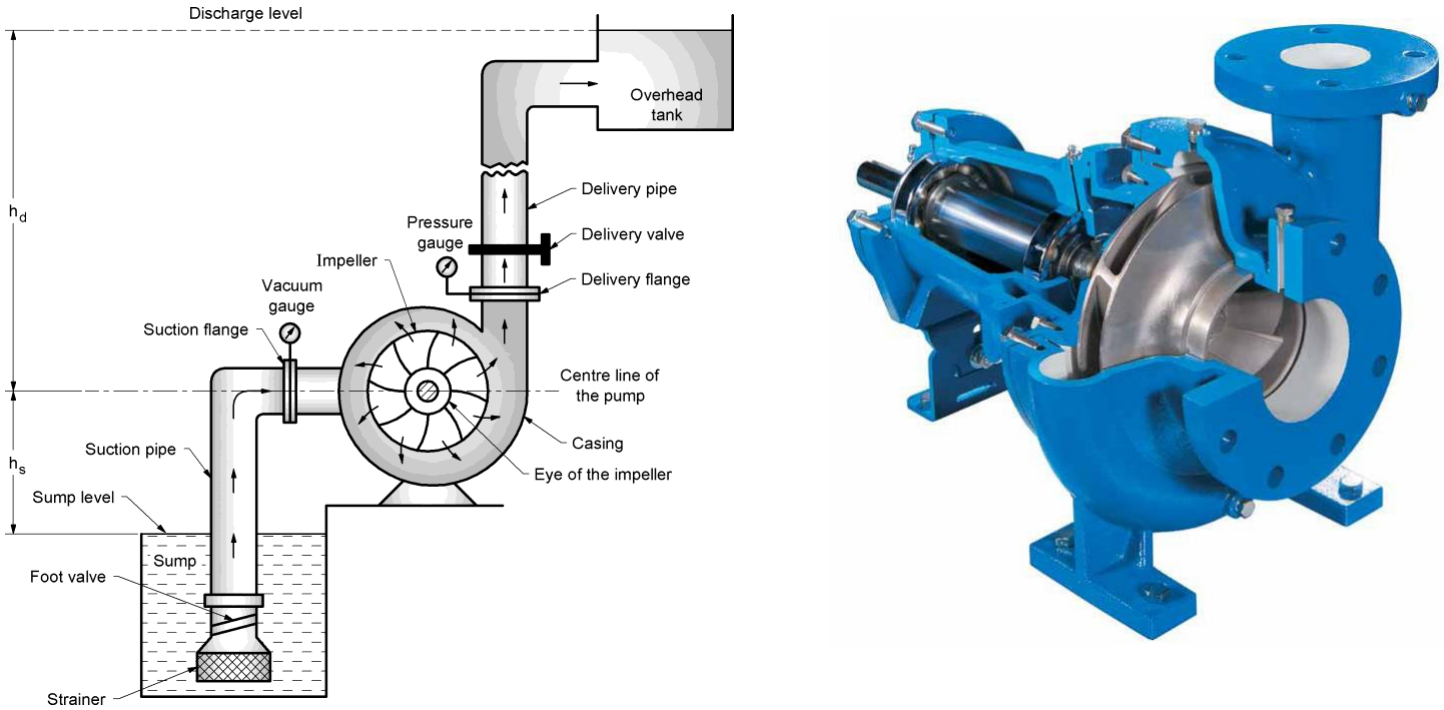


Fig. 6.8.2: Components of Centrifugal pump

A centrifugal pump has the following main components as shown in Fig. 6.8.2.

(1) Impeller: The rotating part of a centrifugal pump is called impeller. Whirling motion is imparted to the liquid by means of finite number of backward curved vanes (usually 6 to 12) provided on the impeller. The impeller is mounted on the shaft which is coupled to the shaft of the electric motor.

(2) Casing: It is an air tight passage surrounding the impeller. It contains

(i) Pump impeller,

(ii) Support for impeller bearings and

(iii) Openings for water inlet and outlet.

The functions of casing are:

(a) To guide water to and from the impeller.

(b) It is designed with gradually increasing area, hence when water flows through the casing the kinetic energy of water is converted into pressure energy before water leaves the casing.

(3) Suction pipe with foot-valve and strainer

(i) The upper end of the suction pipe is connected to the centre (eye) of the impeller and the lower end is submerged into the sump from which water is to be pumped. The pipe has to be air tight with no formation of air pockets.

(ii) Suction pipe is provided with strainer at its lower end so as to prevent the entry of solid particles, debris etc. into the pump.

(iii) A foot valve (non-return valve) is located above the strainer which allows the flow of water only in upward direction. Therefore, this valve does not allow the liquid to drain out of the suction pipe.

(4) Delivery pipe

One end of the delivery pipe is connected to the outlet of the pump and other end is connected to the overhead tank at required height. A valve is provided in the delivery pipe near the outlet of the pump called delivery valve. Its function is to regulate the supply of liquid from the pump to delivery pipe.

6.8.3 Working of Centrifugal Pump:

A centrifugal pump works on the principle that when a certain mass of liquid is made to rotate by an external prime mover, it is thrown away from the central axis of rotation and a centrifugal head is imparted which raises the liquid to higher level.

The steps involved in operation of centrifugal pump are as follows:

(1) The delivery valve is closed and the suction pipe, casing and portion of the delivery pipe upto the delivery valve is completely filled with the liquid so that no air pocket is left. This process is called priming.

(2) The electric motor is started which rotates the impeller. The delivery valve is kept closed. This creates strong suction or vacuum at the eye of the impeller and causes the liquid to rise into the suction pipe from the sump.

(3) The speed of the impeller is gradually increased till the impeller rotates at its normal speed.

(4) After the impeller attains its normal speed, the delivery valve is opened. Now the liquid is continuously sucked by the suction pipe and passes through the centre (eye) of the impeller. The liquid is allowed to flow through the impeller vanes and attains higher velocity and comes out at the outlet tip of the vanes into the casing. As the casing is designed with a gradually increasing area, the velocity of the liquid decreases and pressure head increases.

(5) From casing, the liquid passes into the delivery pipe and is lifted to the required height.

(6) When the pump is stopped, the delivery valve should be closed to stop the backflow of liquid, but if a foot valve (non-return valve) is provided then it is not necessary to close the delivery valve as it will not allow the back flow to occur.

Application: Fire protection system, Pharmaceutical, Chemical & Food Industries, Waste Management, etc.

6.9 RECIPROCATING PUMP

Reciprocating pump is a mechanical device which is used to deliver the liquid with the help of a piston which reciprocates inside a closed cylinder. Reciprocating pump is a positive displacement pump.

6.9.1 Main Components of Reciprocating Pump:

1. Suction Pipe:

Suction pipe connects the source of liquid (Sump or reservoir) to the cylinder of the reciprocating pump. The liquid is sucked by this pipe from the source to the cylinder.

2. Piston & Cylinder:

Contrary to centrifugal pumps, which have impellers, reciprocating pumps use pistons or plungers that move back and forth within the cylinders, creating suction and elevating pressure. This cylinder made of steel alloy or cast iron contains an arrangement of pistons and piston rods.

3. Crank & Connecting rod

The crank is attached to a prime mover, which could be an engine or an electric motor. As shown in the figure, this crank is then joined to the connecting rod. Thus, the rotary motion of the crank is converted into the reciprocating motion of the piston rod.The connecting rod is used to connect the piston rod to the Crank.

4. Suction Valve

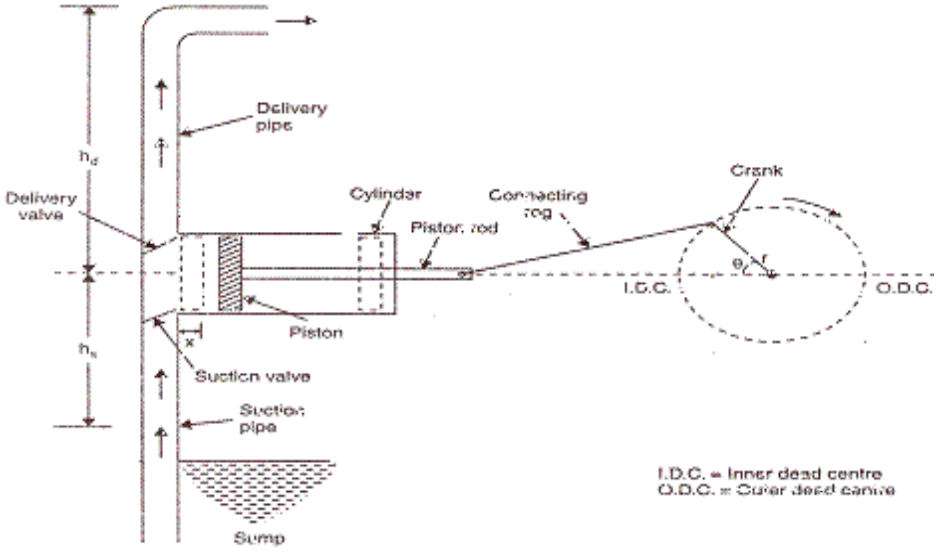
Suction valve is non-return valve (one directional flow). This is placed between suction pipe inlet and cylinder. During suction of liquid, it is opened and during discharge it is closed.

5. Delivery Valve

Delivery valve also non-return valve placed between cylinder and delivery pipe outlet. It is in closed position during suction and in opened position during discharge of liquid.

6. Strainer

A Strainer is attached at the entrance of the suction pipe so as to prevent the entering of any foreign material, dust, debris particles.



6.9.2 Working Principle:

- The crank of the reciprocating pump

is connected to a prime mover like an electric motor or an

engine. Crank and connecting rod convert rotary motion into reciprocating or back and forth motion of the piston.

- Assuming the crank is rotating clockwise (From 0º to 180º), the piston will move from left (IDC) to right (ODC) until it reaches the rightmost position. During this, suction takes place in the cylinder. This stroke is called the suction stroke.
- The liquid is sucked on the left side of cylinder from the sump during this stroke as a vacuum is created within the cylinder.
- The suction also causes the suction valve to open, and the liquid enters the cylinder. At this point, the piston is at the extreme right position.
- Now as the crank rotates further (From 180º to 360º) i.e. from ODC to IDC, the return stroke takes place. In the return stroke, the liquid inside the cylinder is compressed by the piston as it moves from right to left.
- The compression result in a pressure risewhich opens up the discharge valve and the liquid is forced out through the delivery pipe.

Application of Pump in domestic appliances:

6.10 WATER PUMP FOR OVERHEAD TANKS

Working:

- Pumping is used to fill the tank with water from the low height (Usually Ground) to the desired height.
- The high-power motor pumps that deliver the water to storage with high pressure enable this.
- These tanks may be located anywhere over a town or even within your home if they are constructed on the rooftop.
- This automated water pump controller circuit manages the motor of the water pump. When the level of the overhead tank (OHT) drops below the lower limit, the motor is automatically turned on. Similar to that, it is turned off when the tank is filled.

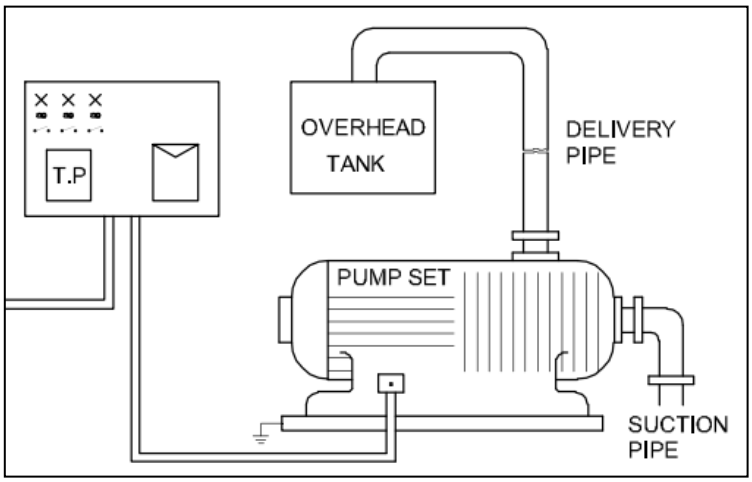


Fig. 6.10: Water pump for overhead tanks

6.11 WATER FILTER/ WATER PURIFIER UNIT:

The procedure of eliminating unwanted chemicals, biological pollutants, suspended particles, and gases from water is known as water purification. Producing water suitable for a range of uses is the aim of this process.

The flavor, fragrance, and look of your drinking water may all be enhanced by water filtration in addition to helping to eliminate potentially hazardous contaminants. It reduces the levels of organic and inorganic pollutants, soil residue, and chlorine.

Main components of Water purifier unit:

1. Sediment filter:

Sedimentation is a physical water treatment method that uses gravity to remove suspended materials from water.The removal of suspended materials like sand, silt, or clay using sediment filtering is a successful way for lowering the turbidity in water.

2. Carbon Pre-filter:

In water purifiers, pre-carbon filters remove sediments, volatile organic compounds, and chlorine from the water**.**

3. Shut off Valve:

The flow of potentially dangerous fluids or outside gases can be safely stopped or continued with the help of shut off valves.

4. RO Membrane:

Reverse osmosis (RO) membranes are semi-permeable membranes that mostly block the passage of dissolved salts, organics, bacteria etc. They enable the passage of water molecules.

Those atoms or molecules that can flow through a semi-permeable membrane but not others are known as semi-permeable. An easy illustration is a screen door. Pests or anything bigger than the openings in the screen door cannot travel through it; only air molecules can.

5. Carbon Pre-filter:

Post-carbon filtration improves water flavor and eliminates odors from the water. By absorbing and getting rid of any last bits of chlorine and other contaminants from the water, the pre-carbon filter.

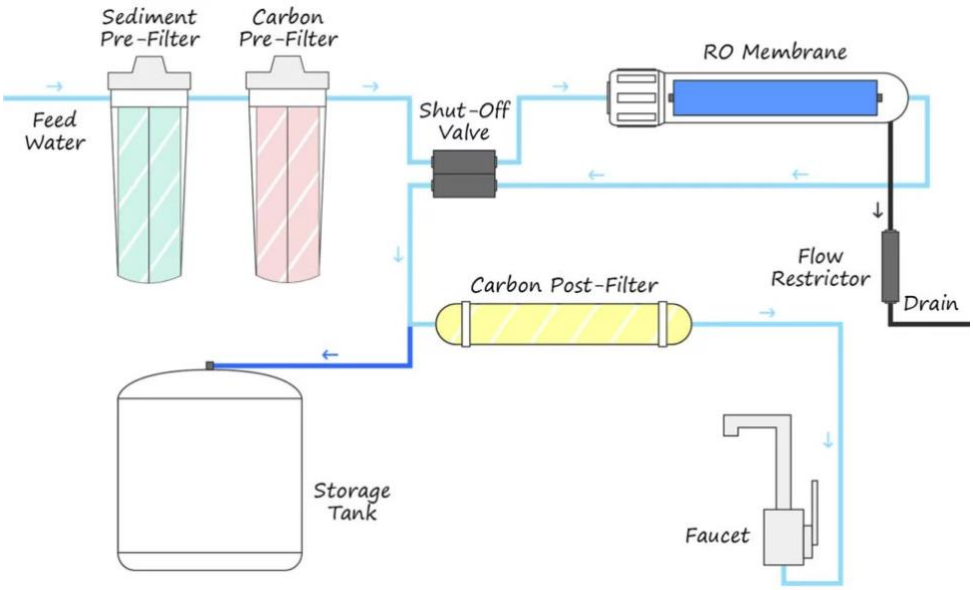


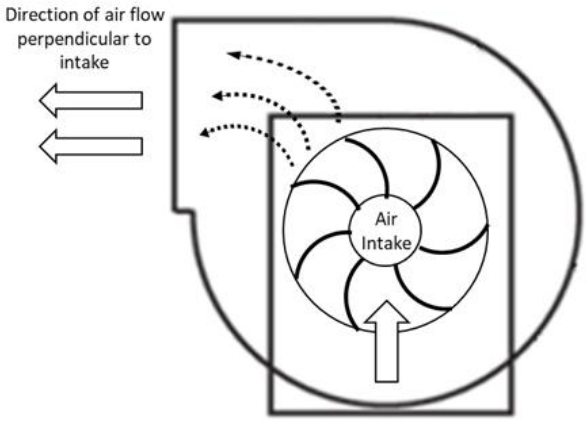
Fig. 6.11: Water Purifier

6.12 BLOWER:

Blower is a device that accelerates the flow of gas or air through their fitted impellers. They are mostly utilized for the flow of air or gas needed for conveying, chilling, ventilating, aspirating, etc.

Through a succession of vortex movements created by the impeller's centrifugal action, blowers raise the pressure of the absorbed gas.

6.12 Fig. of Blower (Fan)



Application of Blower in domestic appliances:

6.13KITCHEN CHIMNEY

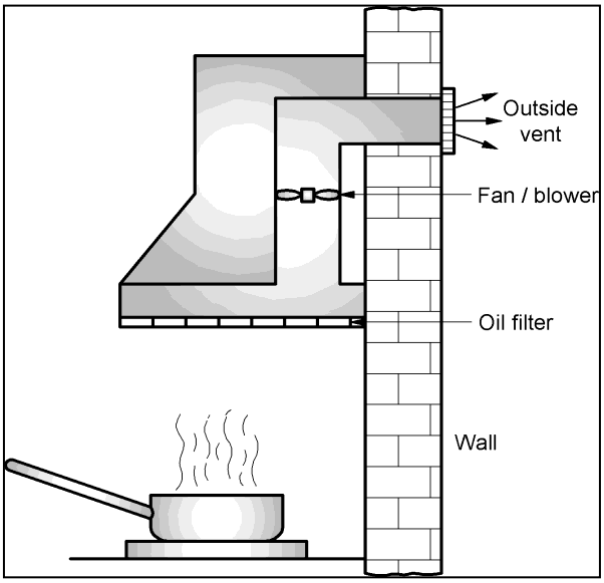


Fig. 6.13: Kitchen Chimney

Basic Principle:

- To keep your kitchen clean and odor-free, a kitchen chimney absorbs heat, smoke, oil, and grease.

- The chimney is made up of two components: an exhaust hood that fits directly over your gas and an air column that links the hood to the outside environment.
- It has a mesh trap that collects the steam and smoke produced while cooking.
- They are pushed forward to the filter once all the gas and steam have been captured.
- The filter captures smoke, grease particles, and oil molecules in the same way that a kitchen chimney does.
- Immediately before the air duct begins, in the exhaust, there is a revolving motor fan. As a result of the air being forced higher up the column by this fan into the duct, ventilation is facilitated.

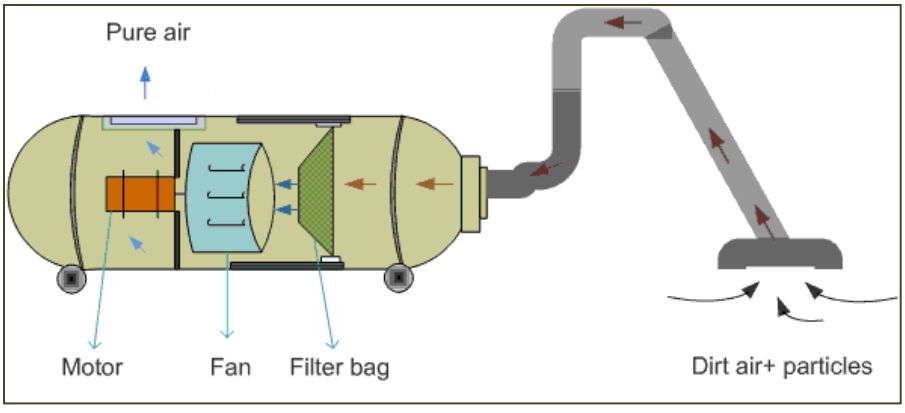
Advantages:

1. Reduces the kitchen's additional heat
2. Maintains the cleanliness of the kitchen's walls, ceiling, and air by removing smoke and soot.

6.14 VACCUM CLEANER

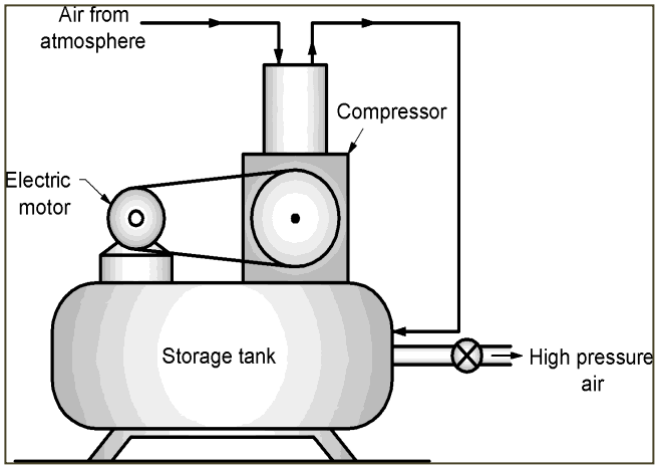
Working of Vacuum Cleaner:

- When a pressure difference exists between two areas, materials move from one region to the other.
- The fundamental operation of a perfect vacuum cleaner is based on these phenomena.
- The addition of external kinetic energy by a centrifugal fan causes the air to flow.
- The fan creates negative pressure behind it as air is drawn in from behind and forced forward with pressure.
- The filter bag is installed before the hose connection on the suction side of this unit's suction and discharge connections.
- The discharge is opened to the environment and has a second air purifier filter. The centrifugal fan and the motor both rotate when electricity is applied.
- As air is drawn into the device from the suction side, it carries all airborne particles to the suction filter, including dirt, mist, and minute solid particles. When they are entrapped in the filter, clean air is forced out of the discharge aperture.



6.15 AIR COMPRESSOR

Compressor is a device used for reducing a gas volume mechanically in order to raise its pressure. The most common gas to be compressed is air, but other industrially significant gases such as natural gas, oxygen, and nitrogen are also get compressed.



6.15 Fig. of Air Compressor

Working Principle of Compressor:

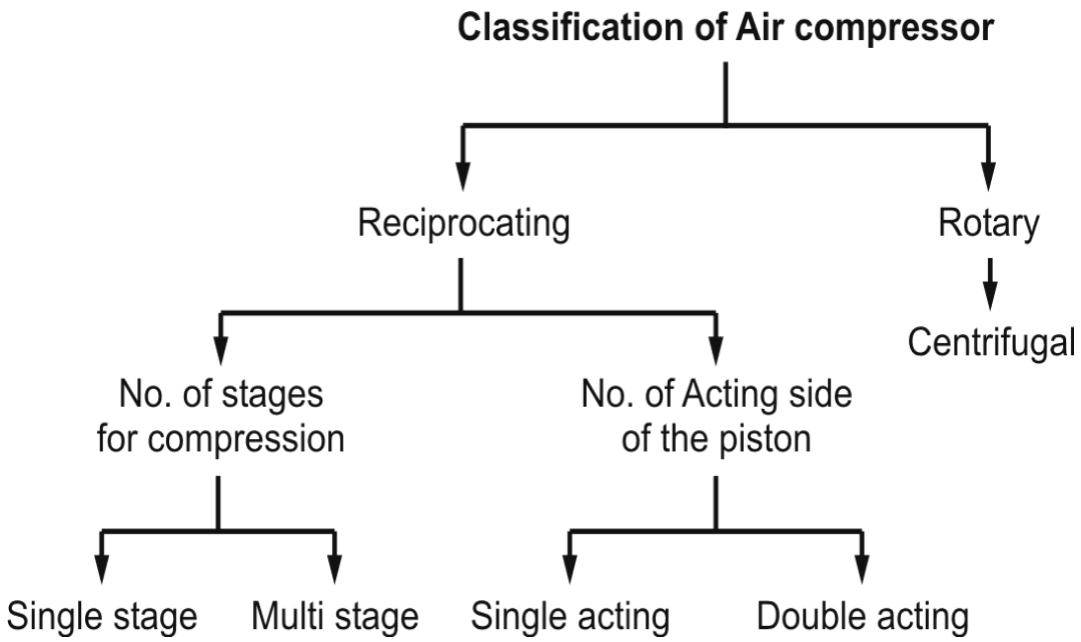
- The function of a compressor is to compress the gases and vapors from low pressure to high pressure.
- According to the second law of thermodynamics, this is only possible when the work is done on the gas by an external agency, such as prime mover, electric motors, etc., using direct and indirect transmission as shown in figure.
- Thus a compressor sucks gas at low pressure (atmospheric air in case of air compressor), compresses it up to a certain pressure and delivers it at high pressure to a storage vessel called receiver (only in reciprocating compressor) from where it may be carried by a pipe line to where it is desired. There are many uses of high pressure air in the industries.

Application:

There are many uses of high pressure air in the industries. The main uses of high pressure air are:

(1) To drive compressed air engines used in coal mines.
(2) To inject fuel as spray into the cylinder of a Diesel engine.
(3) To operate drills hammers, air brakes for locomotives and railway carriage, water pump and paint sprays,
(4) To clean workshop machines, generators, automobile vehicles etc.
(5) To cool large building and aircrafts.

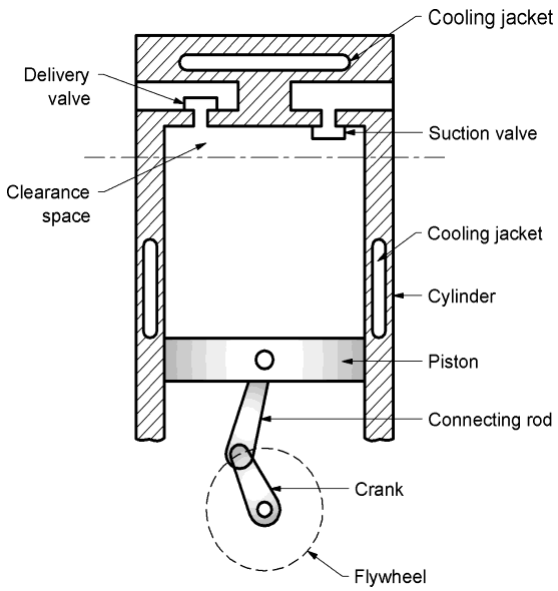
6.16 CLASSIFICATION OF AIR COMPRESSOR:



6.17 RECIPROCATINGAIR COMPRESSOR:

Working Principle:

- A piston in a reciprocating compressor travels downward, lowering pressure in its cylinder by producing a vacuum.
- Due to the pressure differential, the suction chamber valves must open, allowing gas or air to enter.
- By increasing pressure as the cylinder rises, the gas or air is forced out of the cylinder through a discharge chamber.
- Reciprocating compressors are employed for a number of tasks and in a variety of industries.



6.17 Fig. of Reciprocating Air Compressor

Application:

These are the primary uses for reciprocating compressors:

1. Transportation and processing of natural gas
2. Plants that produce chemicals
3. Gasoline stations
4. Technology for refrigeration

Applications of Compressors in DomesticAppliances:

6.18 HOUSEHOLD REFRIGERATOR:

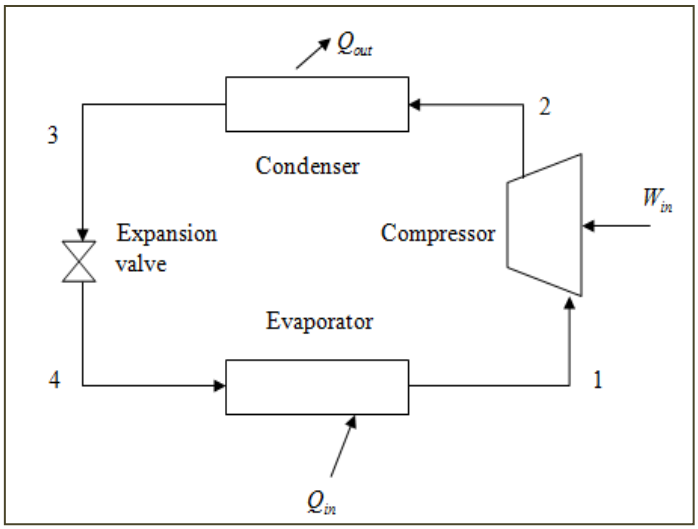
The compressor, condenser, expansion valve/throttle valve, and evaporator are the four elements that make up the vapor compression refrigeration cycle.

Main Components of Refrigerator:

1. **Compressor:**
   The refrigerant enters the compressor at low temperature and low pressure. It is in a gaseous state.Here, compression is used to increase the temperature and refrigerant pressure. The refrigerant exits the compressor and enters the condenser.
2. **Condenser**
   A condenser is a heat exchanger used in heat transfer systems to cool a gaseous substance so that it condenses into a liquid state. By doing this, the substance releases its latent heat and transfers it to the environment.
3. **Expansion valve (Throttle Valve):**
   The expansion valve releases pressure from the liquid refrigerant, allowing it to expand or change state in the evaporator from a liquid to a vapour. The liquid refrigerant entering the expansion valve at high pressure is fairly warm.
4. **Evaporator:**
   An evaporator's purpose in a refrigerator system is to take heat away from the water, air, and other materials inside. The evaporators in refrigerator systems serve as a heat exchanger, transferring heat from the substance and causing it to cool.

6.18.1HOW REFRIGERATION CYCLE WORKS:

- From the evaporator coil, the refrigerant passes via the compressor. The pressure of the coolant increases due to this flow. The vaporized refrigerant then moves on to the condenser, where it becomes liquid.
- The refrigerant releases heat as it transforms into a liquid. This explains why touching the condenser feels warm.
- The refrigerant moves to the expansion valve from the condenser. The expansion valve's pressure drops during this process. The refrigerant goes to the evaporator from the expansion valve.
- The atmosphere around the evaporator serves as a heat source for the liquid refrigerant. The liquid refrigerant is transformed into steam by this heat.



6.18.1 Fig. of Vapor Compression system

The cycle then resumes when the evaporated refrigerant returns to the compressor.

6.19 WATER COOLER

Working Principle:

- The basic cycle of a water cooler is a vapor compression cycle, which is illustrated in Figure below and includes the compressor, condenser, and fan with motor, expansion device, filter or strainer, thermostatic switch, and evaporator coil.
- A thermostatic switch regulates the temperature to our preferred level
- The refrigerant vapor is compressed by the compressor to high temperature, high pressure vapor, which is subsequently condensed in the condenser by the fan motor unit.
- In the condenser, high pressure, high temperature vapor is transformed into high pressure, high temperature liquid.
- A strainer or filter eliminates moisture and any contaminants from the liquid refrigerant.
- An expansion device throttles the liquid refrigerant (generally capillary tube). Pressure and liquid temperature decrease during throttling.
- The heat of the water is subsequently removed from the evaporator tank by this low-pressure, low-temperature refrigerant.
- By absorbing heat from the water, the refrigerant evaporates, and the compressor then absorbs the vapor to continue the process.

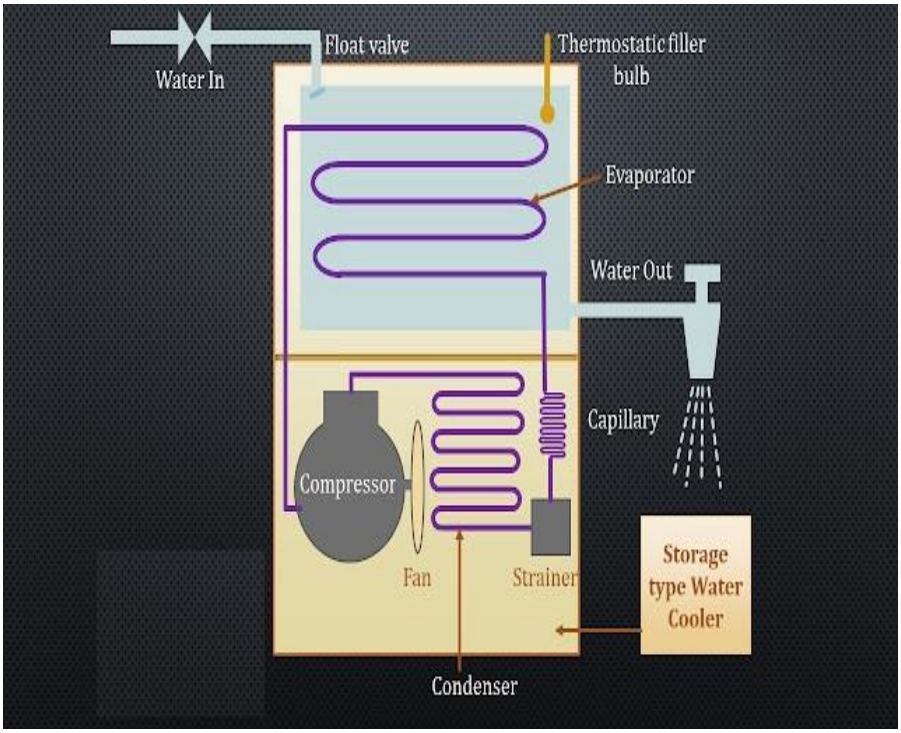


Fig. 6.19: Water Cooler

6.20 SPLIT AC (AIR CONDITIONER) UNIT

A split air conditioner consists of an outdoor unit and an indoor unit. The outdoor unit is installed on or near the exterior wall of the room that you wish to cool. In the heat and humidity of the summer, everyone enjoys returning to a cool and comfortable home. However, window units are noisy and clunky, while central air conditioning is pricey.Cooling your home effectively and affordably can be accomplished with a split air conditioners.

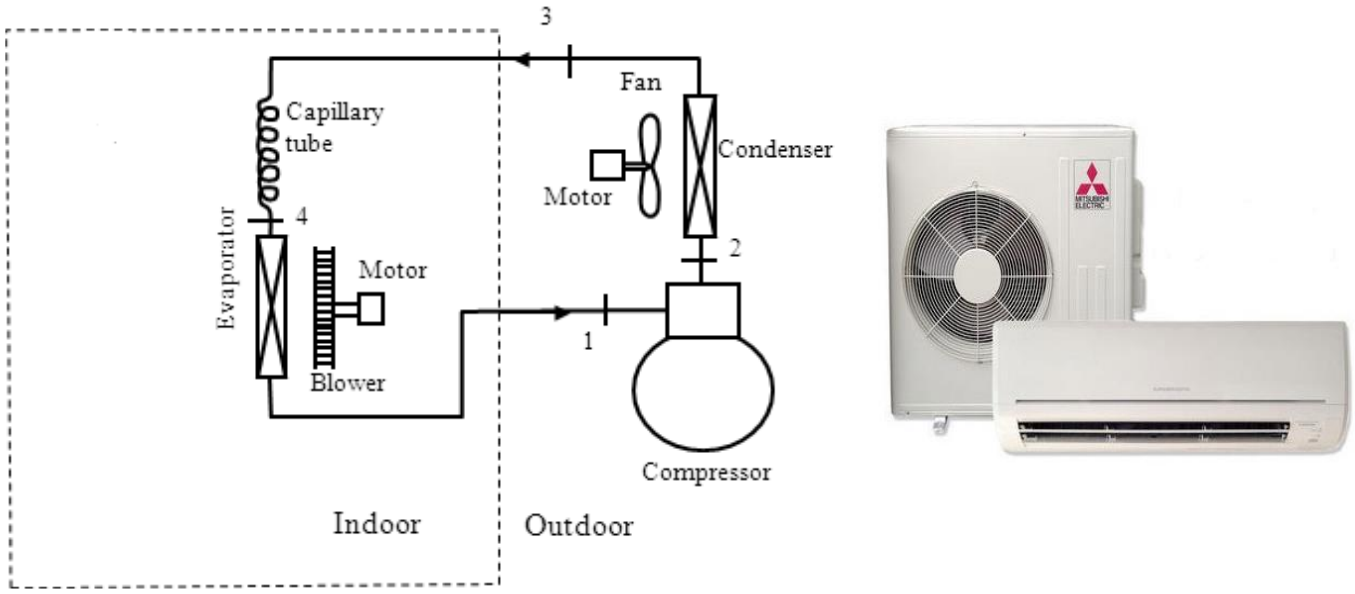


Fig. 6.20: Spilt SC

Parts of Indoor Unit:

Evaporator coil:

This coil is used for cooling. The evaporator absorbs heat from the ambient air as it passes over it, causing it to cool.

Blower:

This device is used to remove hot air from a space and then the hot air is brought into contact with an evaporator to help lower its temperature before being circulated back into the space using a blower.

Air filter:

This device is used to filter out airborne dust particles.

Parts of Indoor Unit:

Compressor:

This device is used to raise the refrigerant's temperature and pressure.

Condenser:

It is used to reject heat to the atmosphere, which causes a drop in refrigerant temperature and pressure.

Propeller fan:

It circulates conditioned air through the condenser, transferring heat to the atmosphere.

Expansion: It lowers the pressure.

Working Principle of Split AC:

- In a split system air conditioner, the refrigerant is located in the exterior unit. The refrigerant is a gas pressurized into the compressor. In a ducted air conditioning unit, the gas travels through a number of tubes. Later, it condenses into liquid.
- The liquid then transforms into a gas as it travels through the expansion joint. During the process, a lot of heat is released.
- The resulting gas is known as a refrigerant because it is used to cool the air at very low temperatures. As the gas enters the compressor once more, this cycle keeps going. Your room's air travels through the chamber containing the evaporator coils. These coils chill the air by holding gas at extremely low temperatures.
- The temperature of air conditioners is controlled by a thermostat, and until the required temperature is reached, the air is kept in the evaporator region. Finally, it is blown into the room space.
- Compared to conventional A/Cs, this type of air conditioner system has several benefits. The silent operation of a split air conditioning system is one obvious advantage. The compressor and the fan that cools the condenser are the components of an air conditioner that produce the most noise. The compressor and condenser fan are positioned outside the area being cooled in a split system, which eliminates the main sources of noise (unlike a window unit).

6.21 SPRING

A spring is an elastic machine component whose purpose is to deform when loaded and then return to its original shape and size when the load is released.

6.22 TYPES OF SPRINGS

- Springs are classified as wire springs, flat springs or special-shaped springs.
- The most commonly used springs in engineering applications are as follows :

1. Helical Springs	2. Torsional Springs
3. Conical and Volute Springs	4. Disc or Belleville Springs
5. Leaf or Laminated Springs	

1. Helical Springs

- A helical spring is formed when a wire is wound around a cylinder in the form of a helix.
- Cross section of the wire may be circular,square or rectangular.
- Depending upon the type of axial load, helical springs are of two types :
-

(a) Helical compression spring
(b) Helical tension spring

(a) Helical compression spring

- A helical compression spring is an open coiled springs.
- The wire of the spring is wound in such a way that there is gap between two consecutive turns.
- Due to gap between the coils, there springs can take compressive loads. (Fig. 6..1)

6.22.1: Helical compression spring

(b) Helical tension spring

- A helical tension spring is a closed coil spring wound with some initial tension.
- Initial tension is given to this spring so that it does not begin to extend until external load is applied.

Fig. 6.22.2: Helical tension spring

2. Torsional Springs

- There are two types of torsion springs i.e. helical torsion spring and spiral torsion spring.
- A helical torsion spring is used in door closers and automobile starters. (Fig. 6.10.3)
- A spiral torsion spring is used mechanical watches and clocks. (Fig. 6.22.4)

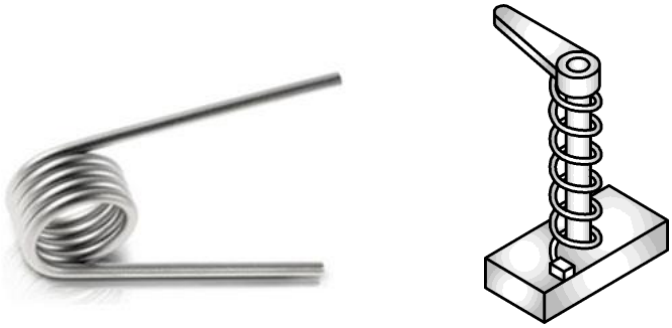
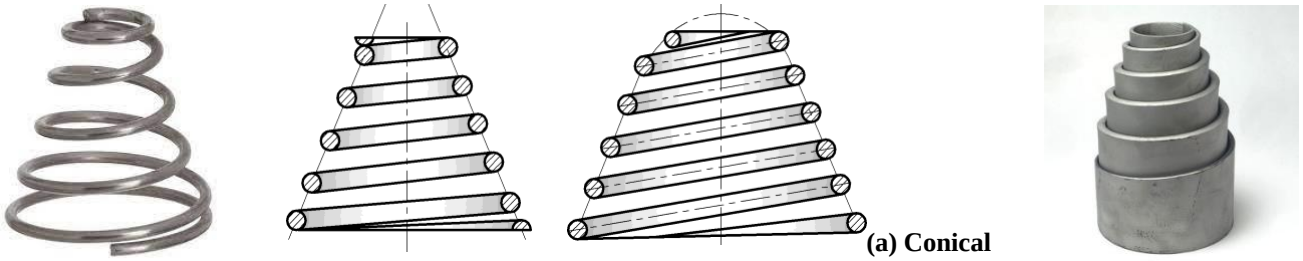


Fig. 6.22.3 :Helical torsion Spring

Fig. 6.22.4 : Spiral torsion spring

3. Conical spring & Volute springs

- In case of conical and volute springs, the spring **rate increases** with **increasing load.**
- In these springs the number of activecoils decrease as load is increases.
- Due to decrease in active coils, the spring rate increases. (Fig. 6.22.5(a) and (b)



(a) Conical spring **(b) Volute springs**

Fig. 6.22.5: Conical & Volute spring

4. Leaf or Laminated Springs

- It is made up of number of plates (known as leaf) which are reducing in length. (Fig. 6.22.6)
- The longest leaf is called as main leaf or master leaf and other leaves are called graduated leaves.
- The spring is clamped to axle by means of U-Bolts.
- Leaf spring is a suspension spring used in heavily duty automobiles and railway.

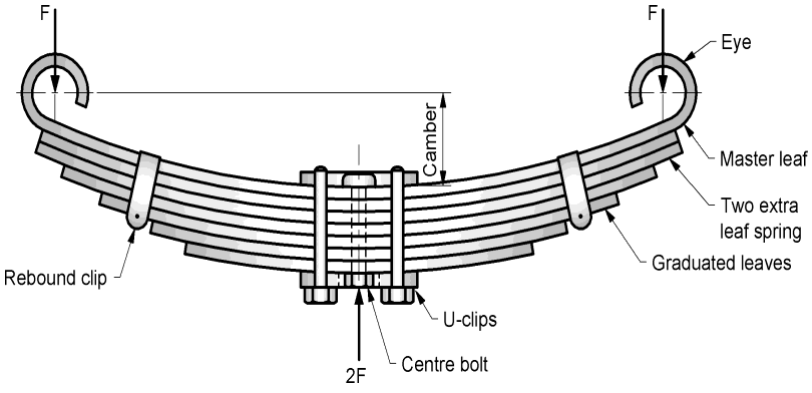


Fig. 6.22.6: Leaf or laminated spring

Application of springs

Springs are used in machinery for following applications

a) In clutches, brakes and spring valves springs are used to apply force (Helical tension or compression spring).

b) In spring toys, watches and cameras springs are used to store energy and then release that energy when required (Torsion spring).

c) In vehicle suspension systems and elevator buffer springs, they are used to absorb shocks and vibrations (Leaf spring).

d) In spring balance, spring is used to measure magnitude of force (Helical tension spring).

TYPES OF SPRINGS

Helical Compression Spring

Helical Extension Spring

Conical Spring

Torsion Spring

Laminated or Leaf Spring

Disc or Belleville Spring

Domestic Applications of Springs

6.23 DOOR CLOSER MECHANISM

The door closer operates on the basis that when the door is opened, the door body moves the connecting rod, which then moves the rack plunger to the right by rotating the transmission gear. The spring and hydraulic oil in the right chamber are both compressed during the right movement of the plunger. Under the influence of oil pressure, the one-way valve ball on the plunger's left side opens, allowing hydraulic oil in the right cavity to flow into the left cavity.

Since the spring is compressed during the door opening process, the stored elastic potential energy is released after the door has opened, and the plunger is then pushed to the left to cause the transmission gear and the connecting rod for the door closer to rotate, causing the door to shut.

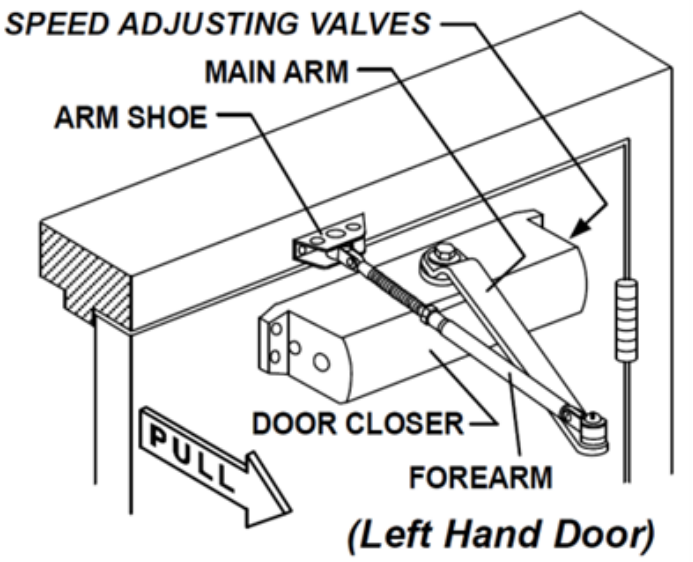
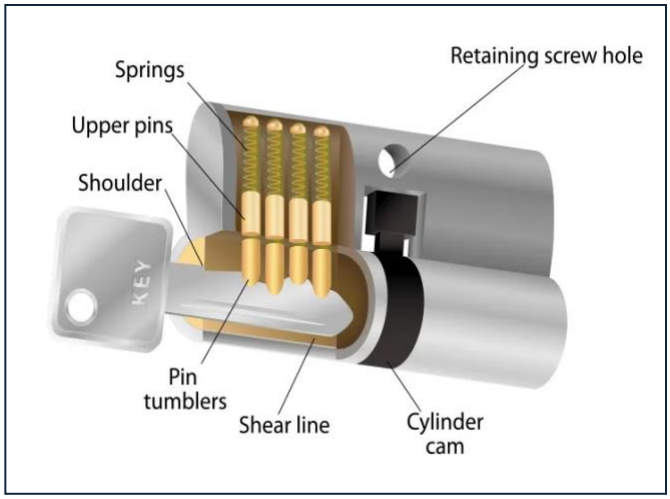


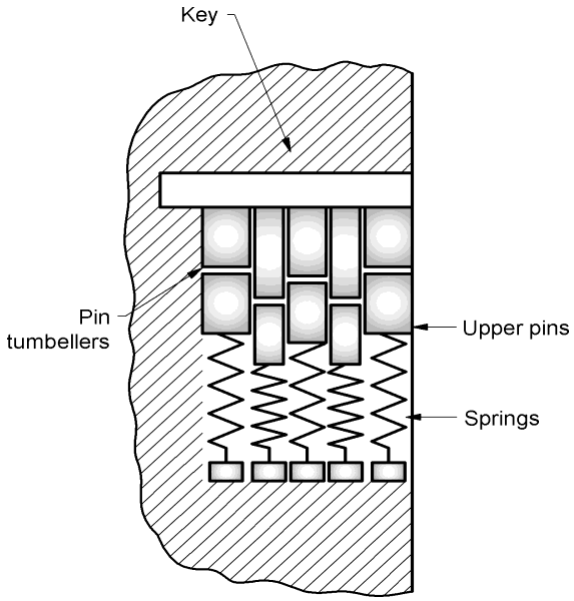
Fig. 6.23 – Door Closer

6.24 DOOR LOCK MECHANISM

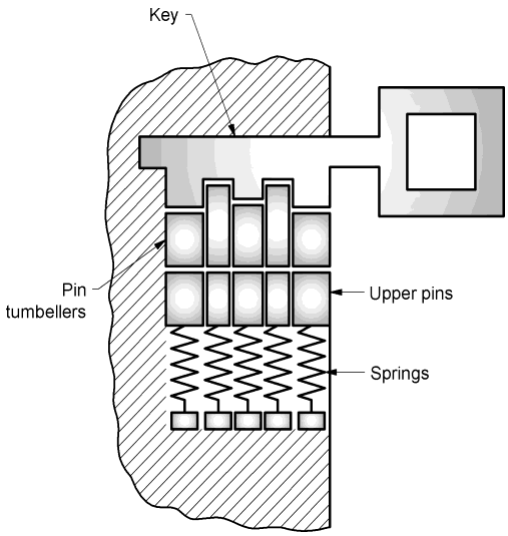
Construction & Working:

- In between the pin tumblers & springs, the upper pins are mounted.
- The pin tumblers are positioned inside the lock's barrel, and the spring and top pins are fully extended.
- When a key is inserted into the lock, it presses on the pin tumblers, driving them into the upper chamber pins and squeezing the springs.
- The pins are then pressed until they are flush with the shear line.
- The pins are made to have various configurations and heights.
- These will line up with the cuts and dents on the proper key.
- The pins are correctly aligned when a key meeting the lock's profile is inserted. As a result, the key can turn because there are no pins blocking the shear line.
- Once the key has rotated the barrel, the cam that rotates to catch the lock's bolt is activated. The lock may be made to unlock or lock with this rotation.





Normal door lock position



Door lock position using Key

Fig. 6.24: Door Lock Mechanism

Use of Electric & Solar Energy in Domestic Appliances:

6.25 ELECTRIC IRON:

The concept of the heating action of current forms the foundation of an electric iron. According to this theory, heat is produced when an electric current passes through a conductor because of the conductor's resistance. Electrical energy is converted into heat energy by the resistance.

An Electric iron draws electricity from the mains and heats a coil inside. This heat is then transferred to the bottom plate, which is pressed to remove wrinkles on clothing.

Working Principle:

- The fundamental idea behind how the electric iron operates is that a wire heats up when a current is put across it.
- In order to remove wrinkles from the garment, this heat is transferred through conduction to the sole (base) plate of the electric iron.
- A thermostat is wired in series with the heating element. Two electrical connections that are used to make the thermostat are made to stretch apart when the iron heats up.
- The knob adjusts the angle at which the contacts must bend in order to separate and sever the electrical connection.
- The iron must get hotter before the electrical connections separate the higher the thermostat is turned.
- When the iron begins to cool, the contacts reconnect, maintaining the desired temperature gradually.
- In essence, you supply a voltage to a load (the heating element of the iron) which causes a current to be induced.
- The greatest attributes of nichrome are its resistance to heat and to corrosion and oxidation.

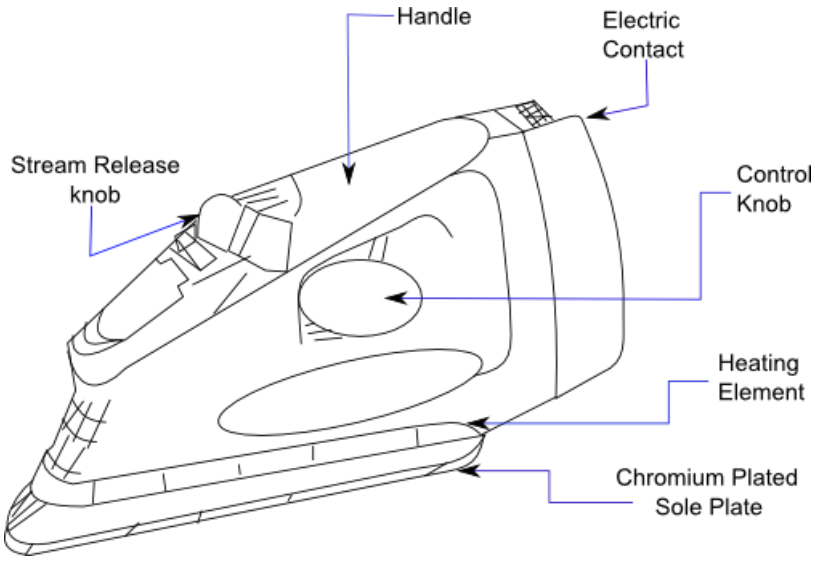


Fig. 6.25 for Electric Iron

6.26 SOLAR WATER HEATER:

Construction:

- In solar water heaters, a copper pipe with a black-painted exterior is installed as a coil inside a box with a black interior.
- The outside surface of copper tubes and inside walls of the box's are painted black to improve heat absorption and produce high temperatures.
- Similar to a solar cooker, a solar water heater's box is covered with a glass sheet to retain heat inside.
- As the solar radiations reaches and imparts on the solar collector, it traps most amount of heat inside the unit which increases the temperature of collector unit converting into heat.
- This ultimately transfers the heat to water flowing through the pipeline connected to it converting cold water to hot water.
- The bottom of the water storage tank is where one end of the copper pipe is connected, and the centre is where the other end is connected.
- Figure depicts a solar water heater's schematic layout.

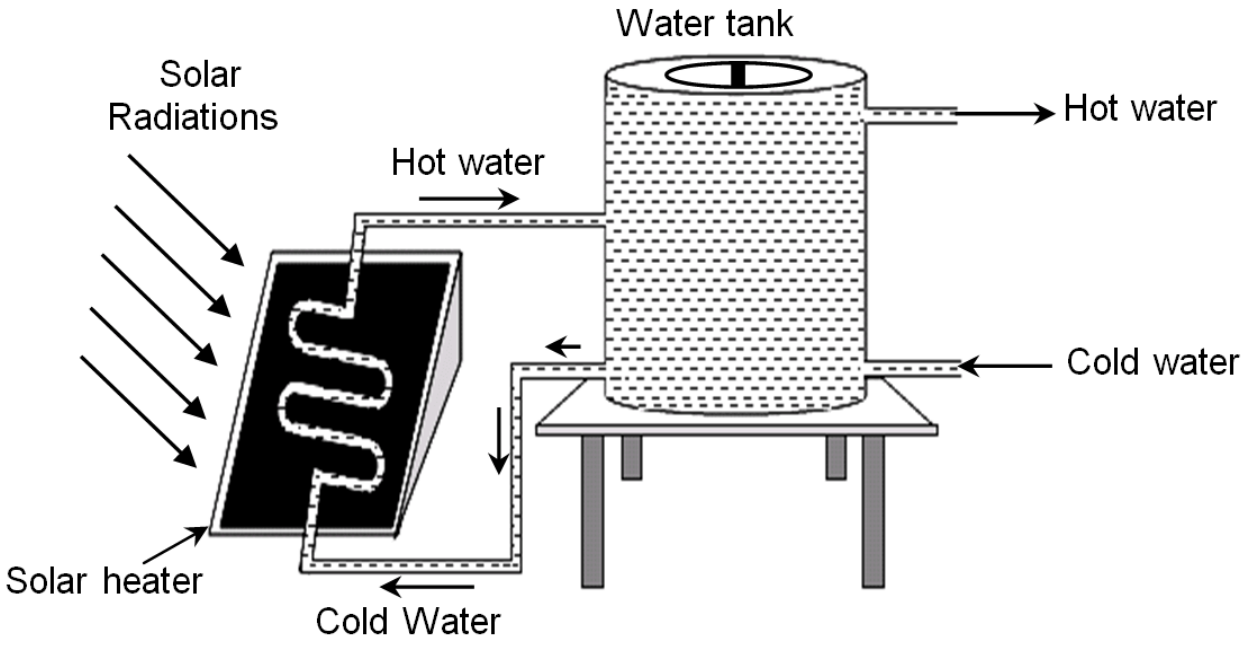


Fig. 6.26 for Solar water heater

Working Principle:

- The cold water in the water storage tank enters the copper pipe that is connected to it at the bottom and gently flows through the copper coil housed in a box.
- Cold water is heated by solar heat as it travels through the copper coil.
- The hot water enters the upper portion of the water storage tank from the other end of the copper line. The cold water in the tank is used to replenish this hot water. All the water in the storage tank eventually warmed up in this manner.
- As hot water is lighter than cold water, it stays in the upper half of the tank. The hot water is provided to a tap from the storage tank's upper section.

6.27 ELECTRIC GEYSER:

Construction:

The geyser is made up of a water tank with two pipes attached to it: one for cold water entry and the other for hot water outflow. The heating components in the water tank are controlled by thermostats. The thermostats make sure that water doesn't get too hot. The tank is often coated with an insulating substance and housed in a metal shell.

Fig. 6.27: Electric Geyser

The water tank is equipped with heating elements that are regulated by thermostats. The thermostat's purpose is to set the temperature at a specific level so that water does not become heated over that level.

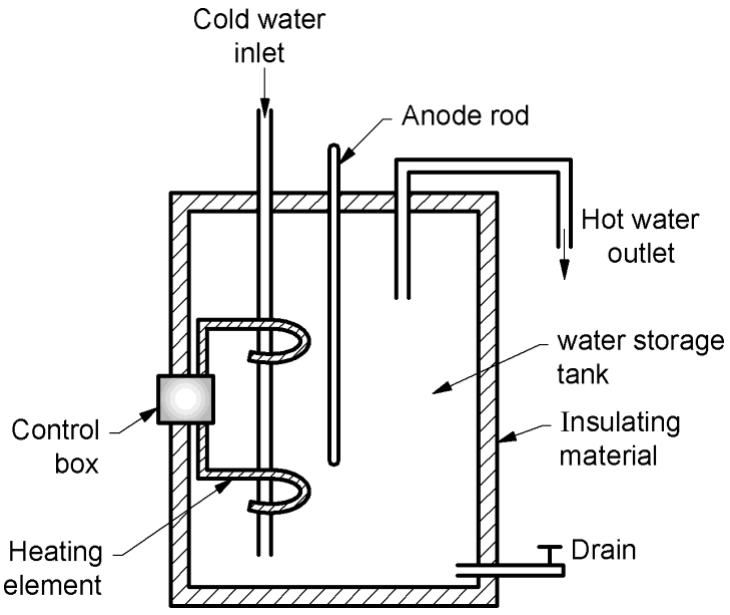
Working Principle:

- A valve controls the flow of cold water as it enters the heating chamber from the cold-water supply pipe (inlet pipe). Through the hot water pipe, hot water exits the heating chamber's top (outlet pipe).
- An anti-drip mechanism is included with the hot water pipe to stop the rapid flow of hot water and to stop water from draining out of the cold-water pipe valve when the cold-water supply fails.
- When the cold-water input valve is opened, the cold-water rushes into the heating chamber, displaces, and forces out an equal amount of hot water out the hot water outlet pipe since the hot water pipe is an open outlet.

6.28 GEARS

Gear Drives:

Gears are defined as the toothed wheels which transmits power and motion from one shaft to another by means of **successive engagement of teeth**.Gear drives offer following advantages-disadvantage over the chain or belt drives.



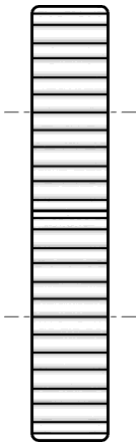
Advantages

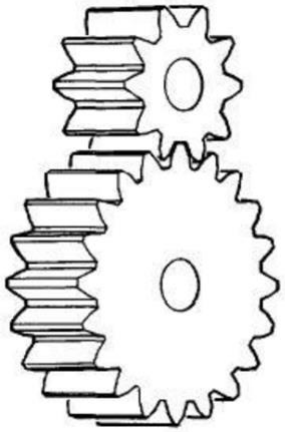
(1) It is a **positive drive** and the velocity ratio remains constant.
(2) The centre distance between the shafts is relatively small, which results in **compact construction**.
(3) It can **transmit very large power** which is beyond the range of belt or chain drives.
(4) It can **transmit motion at very low velocity** which is not possible with the belt drives.
(5) The **efficiency** of gear drives is very **high** up to 99% in case of spur gear.

(6) A **provision** can be made in the gearbox for the **gear shifting**, by just changing the velocity ratio over a wide range.

Disadvantage

(1) The gear drives are costly and the **maintenance cost** is also very **high**.
(2) The **manufacturing process** for gears is **complicated** and highly **specialized**.
(3) Gear drives **require** careful attention for **lubrication** and **cleanliness.**
(4) Gear drives also **require precise alignment** of the shaft.





6.28.1

CLASSIFICATION OF GEARS

Gear is defined as a wheel with teeth around its rim that mesh with the teeth of another wheel to transmit motion. Gears are used to transmit power (as in a car transmission) or change the direction of motion in a mechanism (as in a differential axle).

Gears can be classified into many types based on several criteria. The classification of gears is listed below;

(A) Based on the position of axes of the shaft

(i) Parallel shaft gears: Spur gear; Helical Gear
(ii) Intersecting shaft gears: Straight bevel gear; Spiral bevel gear; Zerol bevel gear
(iii) Non-parallel and non-intersecting shaft gears: Worm gear; Screw (crossed helical gear)

(B) Based on the type of gearing: Internal gear; External gear; Rack and Pinion

(C) Based on the tooth profile on the gear surface:
Gears with- straight teeth; curved teeth; inclined teeth

(D) Based on the peripheral velocity of gears:
Low velocity gears (V< 3 m/s); Medium velocity gears (V = 3-15 m/s); High velocity gears (V > 15 m/s).

The commonly used gears are discussed below.

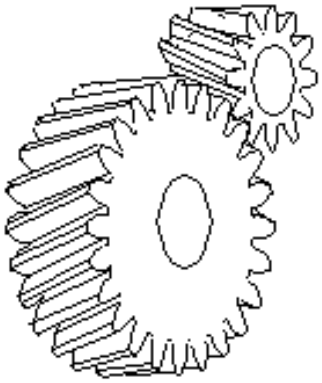
(1) Spur Gear: Spur gear or straight cut gears are the simplest type of gear. They consist of a cylinder or disk with the teeth projecting radially, and although they are not straight –sided in form, the edge of each **tooth is straight** and aligned to the axis of rotation. These gears can be meshed together correctly only if they are fitted to parallel shafts.

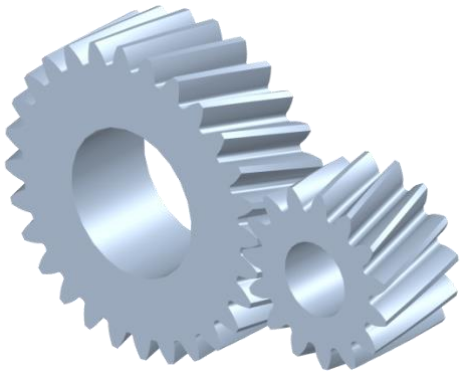
Pinion ⟸

(2) Helical Gear: Helical gears offer a refinement over spur gears. The leading edges of the **teeth** are not parallel to the axis of rotation, but are set at **an angle**. Since the gear is curved, this angling causes the tooth shape to be a segment of a helix. Helical gears can be meshed in parallel or crossed orientations.

Advantages of Helical gears

1. In  helical gear, the **dynamic load** is **less** because of gradual engagement.
2. In helical gears, the **contact ratio** is **high** as compared to spur gears.
3. In helical gears, the contact between the meshing teeth begins as a point contact and gradually extends along the diagonal line across the tooth. This gradual engagement results in **smoother** and **quieter operation** even at high pitch line velocities.

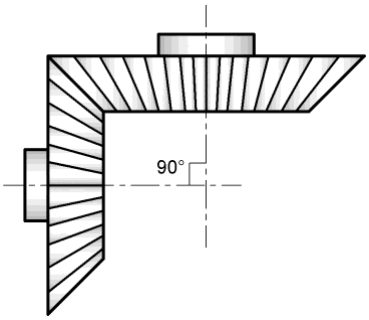




Disadvantages of Helical Gears

1. Helical gears **create axial thrust** on the shaft and the bearings.
2. Helical gears are **costlier** than spur gears.

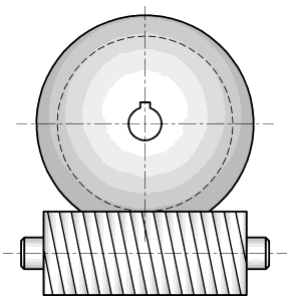
(3) Bevel Gear:A bevel gear is s**haped like a right circular cone** with most of its tip cut off. When two bevel gears mesh, their imaginary vertices must occupy the same point. Their shaft axes also intersect at this point, forming an arbitrary non-straight angle between the shafts. The angle between the shafts can be anything except zero or 180°. Bevel gears with equal number of teeth and shaft axes at 90°are called **miter gears.**

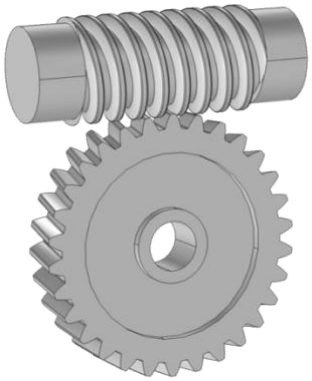


(4) Herringbone Gears:

A herringbone gear, a specific type of double helical gear, is a special type of gear which is a **side to side combination of two helical gears** of opposite hands. From the top the helical grooves of this gear looks like letter V. Unlike helical gears they do not produce an additional axial load. It is also called double helical gears.

5) Worm Gears: Worm gear **resembles screws**. A worm gear is usually meshed with a spur or a helical gear, which is called the gear, wheel or worm wheel. Worm gears can be considered as species of helical gear, but its helix angle is usually somewhat large (close to 90 degrees) and its body is usually fairly long in the axial direction.





- **Advantages of Worm Gears**

(1) It has **high speed reduction ratio** from 40 to 100 approximately for single pair.

(2) It gives **compact arrangement**, having small overall dimensions as compared with spur, helical or bevel gear with same speed reduction.

(3) It has **smooth and silent working**.

(4) It can be designed for **self locking** if the efficiency of the worm gear drive is less than 50%. In such a case the motion can be transmitted only from the worm to the worm gear.

- **Disadvantages of Worm Gears**

(1) The **power transmitting capacity** of worm gear drive is **low**.

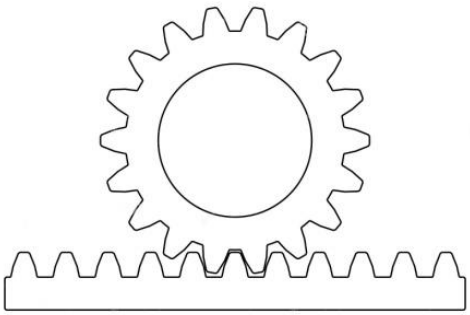
(2) The **efficiency is lo**w.

(3) Considerable amount of heat is generated due to **high frictional losses.**

(4) The worm gears are generally made of phosphor bronze which **increases the cost**.

6) Rack and pinion:

A rack and pinion is a particular kind of linear actuator that consists of two gears that transform rotational motion into linear motion. When rotational motion is delivered to the pinion, the rack moves relative to the pinion, converting the rotational motion of the pinion into linear motion. The rack is a linear "gear" bar with teeth that engage with the teeth on the pinion.



6.29 GEAR TRAIN

Types of Gear Trains

Definition : Gear train : Two or more gears are made to mesh with each other to transmit power from one shaft to another. Such a combination is called gear train.

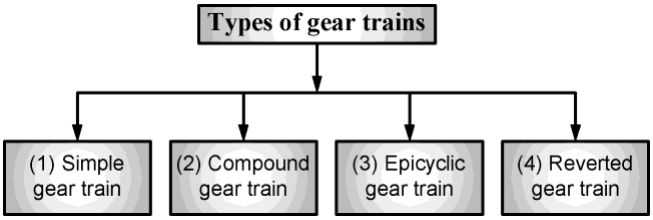


Fig. 6.29.1

1. Simple gear trains

- In a simple gear train each shaft carries one gear and there is an relative motion between the axis of shafts as shown in Fig. 6.13.2.
- Consider gear A and B are in mesh then the peripheral velocity at the point of contact of the gear A and B must be equal.

Peripheral velocity of gear A =Peripheral velocity of gear B

$$\pi D_A N_A = \pi D_B N_B$$

D = Pitch circle diameter

$$\frac{N_B}{N_A} = \frac{D_A}{D_B}$$

$$\frac{N_B}{N_A} = \text{Train value}$$

These gears are represented by their pitch circle diameter.

where

Gear A = Driver gear

Gear C = Driven gear

Gear B = Idler or intermediate gear

N_A, N_B, N_C = Speed of gear A, B, C

T_A, T_B, T_C = Teeth of gear A, B, C respectively

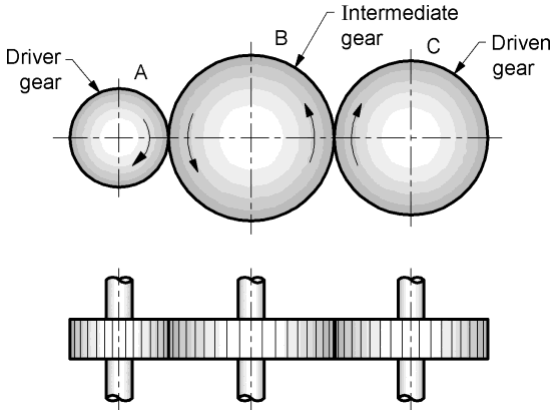


Fig. 6.29.2: Simple gear trains

Train value

Ratio of angular velocity of driven gear to that of driver gear.

As $D \propto T$

$$\text{Train value} = \frac{N_B}{N_A} = \frac{D_A}{D_B} = \frac{T_A}{T_B} \quad \ldots(4.3.1)$$

Similarly the train value of gear B and C.

$$= \frac{N_C}{N_B} = \frac{D_B}{D_C} = \frac{T_B}{T_C}$$

…(4.3.2)

Equation (I) and (II) multiply

$$\frac{N_B}{N_A} \times \frac{N_C}{N_B} = \frac{D_A}{D_B} \times \frac{D_B}{D_C} = \frac{T_A}{T_B} \times \frac{T_B}{T_C}$$

$$\text{Train value} = \frac{N_C}{N_A} = \frac{T_A}{T_C}$$

$$\text{Velocity ratio} = \frac{N_A}{N_C} = \frac{T_C}{T_A} \quad \ldots (4.3.3)$$

Equation (III) represents velocity ratio of simple gear train.

Application

It is used to transmit the power of crankshaft to crankshaft of I.C. engine.

2. Compound Gear Train

In a compound gear train, there are more than one gear on a shaft which are rigidly fixed to it and mesh with the gear in another shaft forming gear train. (Refer Fig. 6.29.3)

Gear A = Driver gear

Gear F = Driven gear

Gear B, C, D, E = Compound gear

For gear A and B

$$\frac{N_B}{N_A} = \frac{D_A}{D_B} = \frac{T_A}{T_B} \quad \ldots (4.3.4)$$

For gear C and D

$$\frac{N_D}{N_C} = \frac{D_C}{D_D} = \frac{T_C}{T_D} \quad \ldots (4.3.5)$$

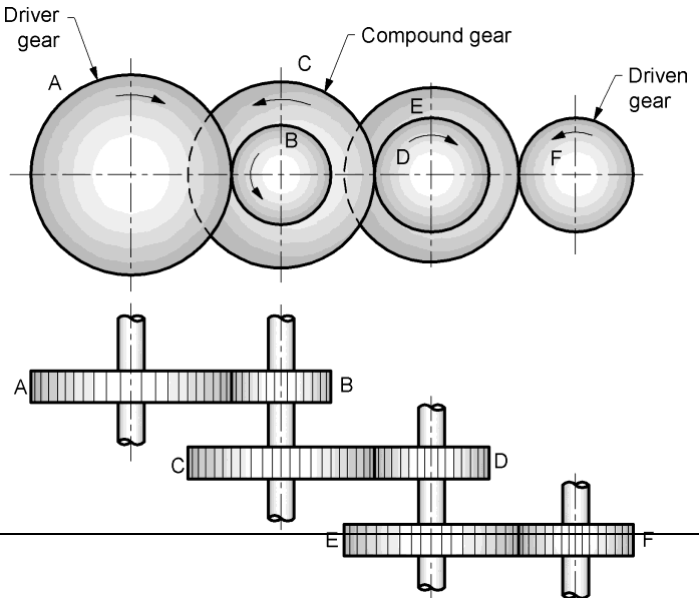
Similarly for gear E and F

$$\frac{N_F}{N_E} = \frac{D_E}{D_F} = \frac{T_E}{T_F} \quad \ldots (4.3.6)$$

$$\text{Train value} = \frac{\text{Speed of driven gear}}{\text{Speed of driver gear}} = \frac{N_F}{N_A}$$

Multiply Equations (6.148.4), (6.148.5) and (6.148.6)

$$\frac{N_B}{N_A} \times \frac{N_D}{N_C} \times \frac{N_F}{N_E} = \frac{D_A}{D_B} \times \frac{D_C}{D_D} \times \frac{D_E}{D_F}$$



$$= \frac{T_A}{T_B} \times \frac{T_C}{T_D} \times \frac{T_E}{T_F}$$

But gear B and C mounted on same shaft also gear D and E are one compound gear mounted on same shaft.

$$N_B = N_C \quad \text{and} \quad N_D = N_E$$

$$\frac{N_F}{N_A} = \frac{D_A \times D_C \times D_E}{D_E \times D_D \times D_F} = \frac{T_A \times T_C \times T_E}{T_B \times T_D \times T_F}$$

$$\text{Train value} = \frac{N_F}{N_A} = \frac{\text{Product of number of teeth on driver}}{\text{Product of number of teeth on driven}}$$

(Fig. 6.29.3: Compound gear train)

The velocity ratio is also called as speed ratio.

$$\text{Velocity ratio of compound gear train} = \frac{\text{Product of diameter of driver pulley}}{\text{Product of diameter of driven pulley}}$$

$$\text{V.R} = \frac{N_A}{N_F} = \frac{D_B\, D_D\, D_F}{D_A\, D_C\, D_E} \qquad \text{Velocity ratio} = \frac{T_B\, T_D\, T_F}{T_A\, T_C\, T_E}$$

Application of gears:

6.30 WALL CLOCK

Components:

1. Battery.
2. Electric stepping motor.
3. Microchip.
4. Circuit connects microchip to other components.
5. Gears turn hour, minute, and second hands at different speeds.

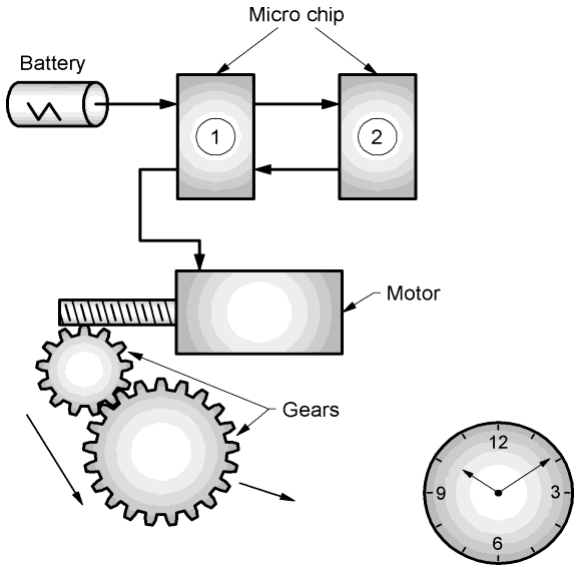
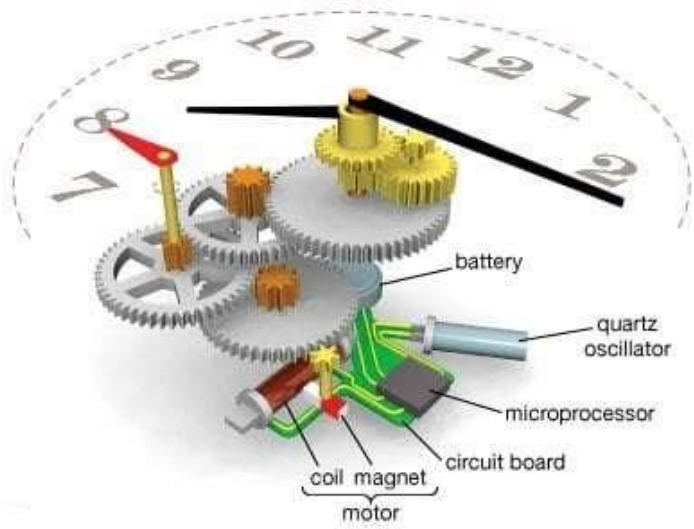


Fig. 6.30: Gear Mechanism in Wall clock



Working Principle:

- The battery powers the quartz crystal within a quartz watch or clock via an electrical circuit. The frequency at which the quartz crystal oscillates (vibrates back and forth) is exact: 32768 times per second.
- The circuit counts the vibrations and uses them to produce regular, one-second electric pulses.
- These pulses can drive a small electric motor (really, a tiny stepping motor) that rotates gear wheels to spin the clock's second, minute, and hour hands, or they can drive an LCD display that displays the time numerically.
- The battery powers the microchip circuit. Quartz crystal, which is carefully cut and shaped like a tuning fork, oscillates (vibrates) 32768 times per second thanks to a microchip circuit.
- The oscillations of the crystal are detected by a microchip circuit, which converts them into regular, one-second electric pulses.
- Small electric stepping motors are propelled by electrical pulses. In doing so, mechanical power is generated from electrical energy.
- A stepping electric motor shifts gears. To keep time, gears move hands around the clock face.

6.31 WATCHES

Components of the Mechanical watch:

Crown:
The wheel on the side of the watch that is used to set time. It can also be turned to wind the watch to run.

Main spring:
The coil-shaped mainspring receives the kinetic energy from winding the crown, and as it gets tighter andtighter, it stores the energy.

Gear Train:
A gear train is a system of tiny gears that transfers the mainspring's stored energy to the Escapement.
It Functions as a brake, dividing the energy transmitted from the mainspring through the gear train into equal, regular pieces.

Escapement:
Escapement, in mechanisms, a device that permits controlled motion, usually in steps. In a watch or clock, it is the mechanism that controls the transfer of energy from the power source to the counting mechanism.

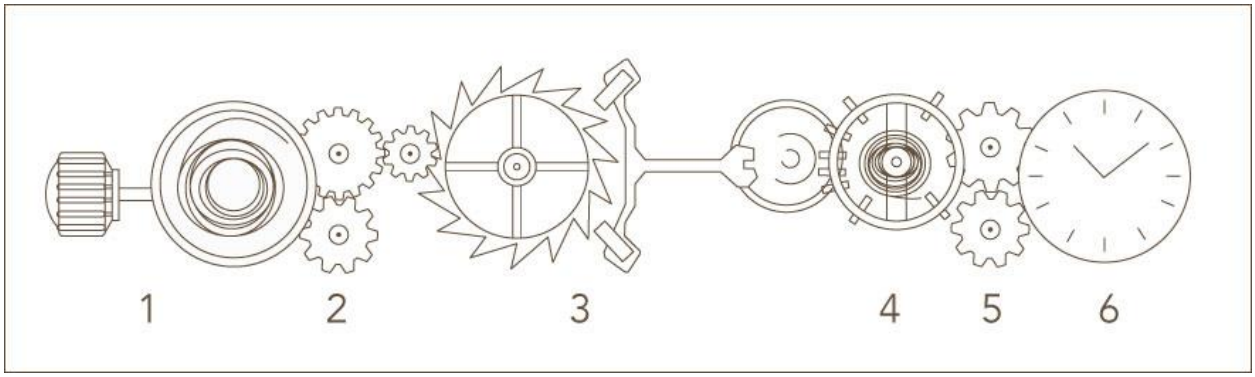
Balance Wheel:
The movement's center, where the energy for escaping the escapement is received. Five to ten times per second, the balance wheel beats or oscillates in a circular manner. The balance wheel can be made to oscillate faster or slower by a watchmaker, which will affect how quickly or slowly the watch runs.

Dial Train:
A second set of gears that transfer the controlled, evenly distributed energy from the balance wheel to the watch's hands, causing them to move.

How Mechanical Watch works:

1. The mainspring is wound as the crown is turned, which causes it to store energy.
2. The energy is transferred to the escapement by the gear train.
3. The energy is metered out by the escapement into controlled portions.
4. The balancing wheel continuously oscillates back and forth using this controlled energy.
5. The dial train transfers energy to the watch's hands every predetermined number of beats.
6. The hands movement propels.

Fig. 6.31: Gears in Mechanical watch



Applications of Gears in Domestic Appliances

6.32 PRINTER

When you print something, your computer transmits a huge stream of electrical data to your laser printer (usually several megabytes or million characters). The meaning of all of this data and how it should appear on the page are determined by an electronic circuit in the printer. It generates static electricity by moving a laser beam back and forth across a drum inside the printer. Toner, a type of powdered ink, is drawn onto the page by static electricity. Finally, a fuser unit, like one in a photocopier, fuses the toner to the paper.

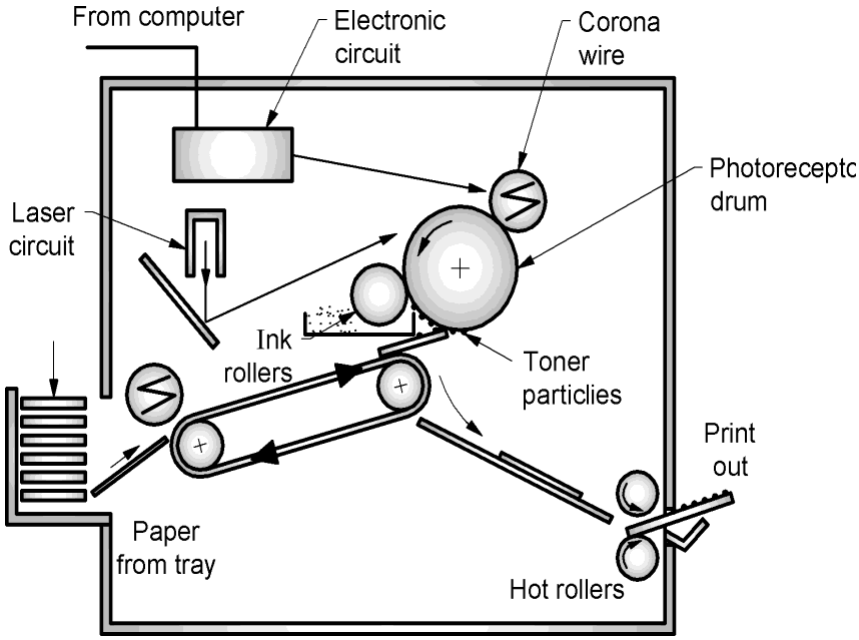
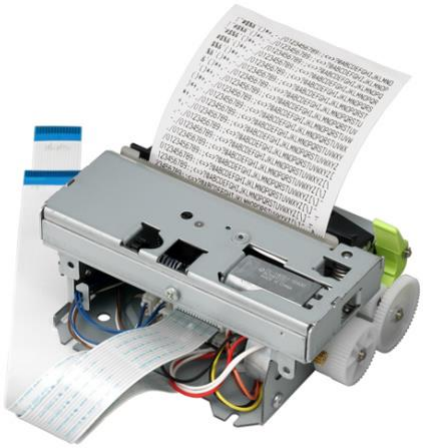


Fig. 6.32: Use of Gears in Printer



1. Data in the millions of bytes (characters) flow from your computer to the printer.
2. This data is printed using an electronic circuit in the printer that functions as a minicomputer on its own.
3. Corona wire activation is done using an electronic circuit. Anything close to this high-voltage line receives a static electric charge.
4. The photoreceptor drum receives a charge from the corona wire that is distributed evenly across its surface.
5. The circuit turns on the laser at the same moment to transfer the page's image to the drum. The laser beam scans across the drum by reflecting off a moving mirror instead than actually moving. The positive charge that was present where the laser beam strikes the drum is eliminated, leaving a negative charge in its place. Over time, a picture of the complete page appears on the drum: areas with positive charges appear where the page should be white, and areas with negative charges appear where the page should be black.
6. The photoreceptor drum is covered with microscopic ink powder by an ink roller (toner). Given a positive electrical charge, the toner adheres to the photoreceptor drum's negative-charged components (remember that opposite electrical charges attract in the same way that opposite poles of a magnet attract). The sections of the drum with a positive charge do not attract ink. On the drum, an inked image of the page develops.

7. On the opposite side of the printer, a sheet of paper is fed up toward the drum from a hopper. A second corona wire gives the paper a high negative electrical charge as it moves.
8. The positively charged toner particles are drawn away from the drum when the paper is moving close to it due to its negative charge. The toner particles are currently only faintly sitting on the paper's surface while the picture is transmitted from the drum to the paper.
9. The inked paper travels via two hot rollers (the fuser unit). The toner particles are firmly bonded into the paper fibers by the rollers' heat and pressure.
10. The printout pops out from the copier's side. The paper is still heated because of the fuser unit.

6.33 BELT DRIVES

6.33.1 Introduction

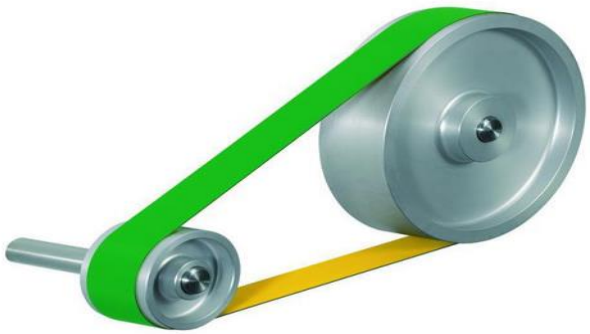
- The belt or ropes are used to transmit power from one shaft to another by means of pulleys which rotate at the same speed or at different speeds.
- The amount of power transmitted depends upon the following factors:
  1. The velocity of the belt.
  2. The tension under which the belt is placed on the pulleys.
  3. The arc of contact between belt and the smaller pulley.
  4. The condition under which the belt is used.
- It may be noted that
  1. The shaft should be properly in line to insure uniform tension across the belt section.
  2. The tight side of the belt should be at the bottom, so that whatever sag is present on the loose side will increase the arc of contact at the pulleys.

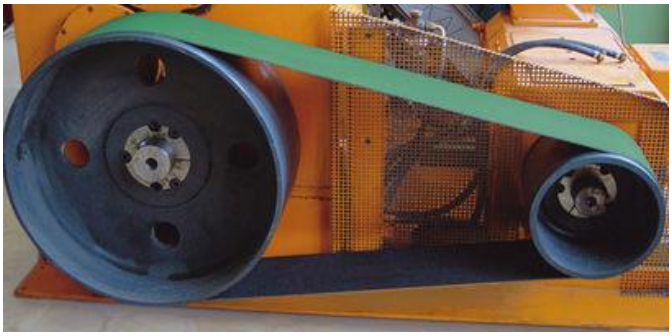
6.33.2 Selection of a Belt Drive

1. Speed of the driving and driven shaft.
2. Speed reduction ratio
3. Power to be transmitted
4. Space available

6.33.3 Types of Drives:

Classification of drives are as follows:





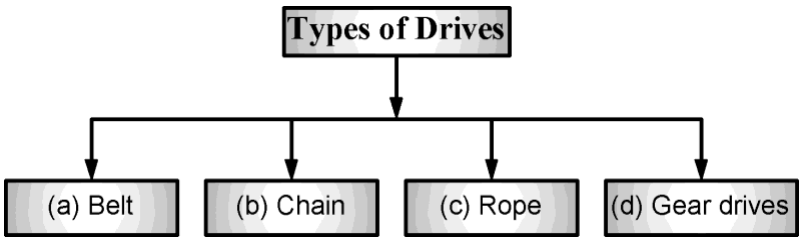


Fig. 6.33.3

6.33.4 Types of Belts:

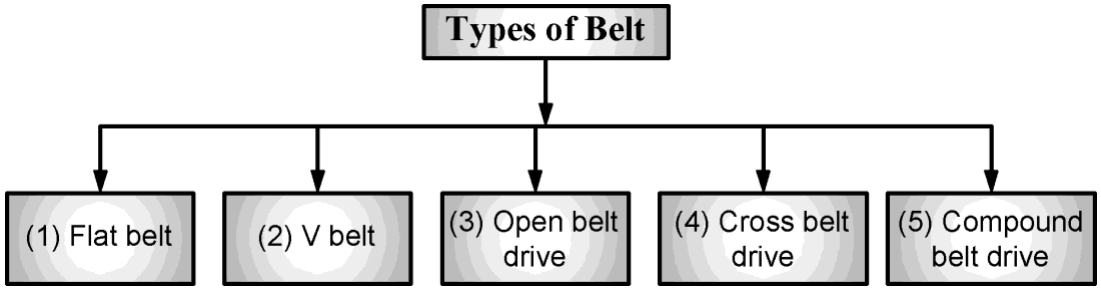


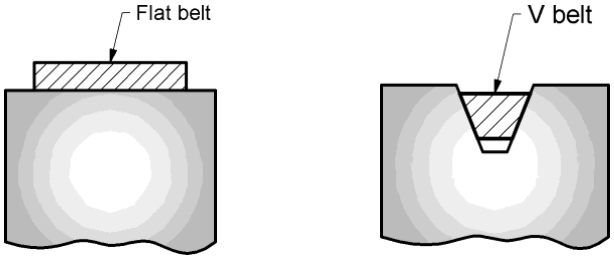
Fig. 6.33.4

1. Flat belt

The flat belt mostly used in factories and workshops, where a moderate amount of power is to be transmitted, from one pulley to another when the two pulley, are not more than 8 meter apart.

2. V-Belt

The V-belt is mostly used in the factories and workshops where a moderate amount of power is to be transmitted, from one pulley to another, when the two pulley are very near to each other.

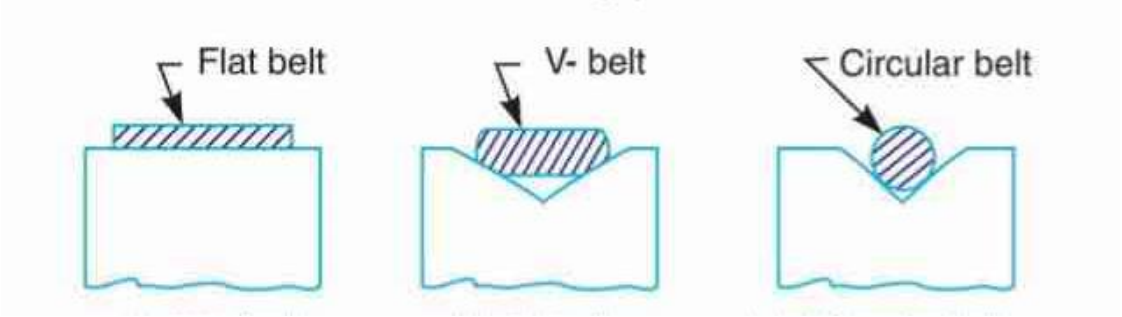


(a) Flat belt **(b) V belt**

Fig. 6.33.4: Types of belts

3. Circular Belt:

This type of belt has a circular cross-section The circular belt or rope is mostly used where a large amount of power is to be transmitted from one pulley to the other, when the two pulleys are apart more than 8m.



6.34 TYPES OF BELT DRIVES

1. Open belt drive:

- Is used with shafts arranged parallel and rotating in the same direction. The driver A pulls the belt from one side and delivers it to other side. Thus the tension in lower side belt will be more than that in the upper side belt.
- Lower side belt is known as tight side and uppers side belt is known as slack side.

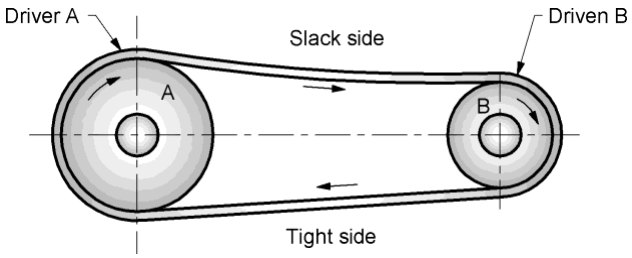


Fig. 6.34.1: Open belt drive

2.Crossed belt drive

- Used for shafts arranged parallel and rotating in the opposite direction. Driver pulls the belt from one side and delivers it to other side.
- Thus, the tension in the belt RQ will be more than in the belt LM and the belt RQ is known as tight side and whereas belt LM is known as slack side.

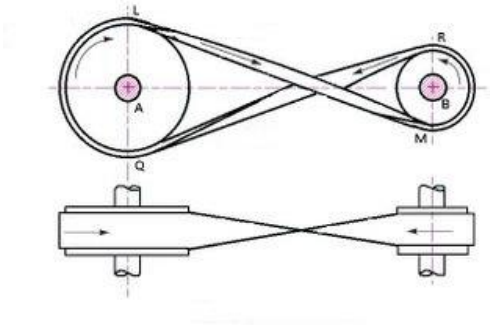
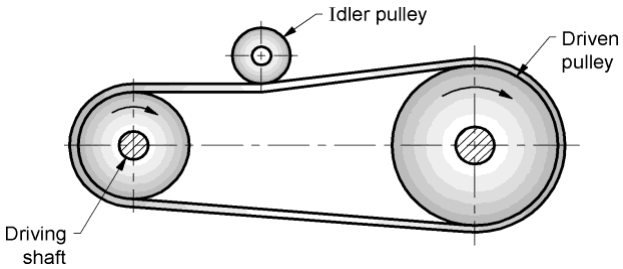


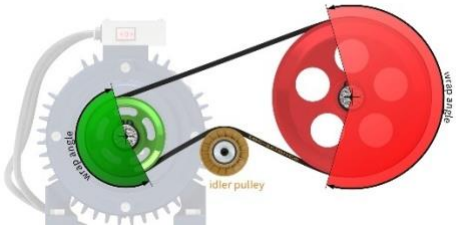
Fig. 6.34.2: Cross or twist belt drive

3. Open belt drive with idler pulley:

When the shafts are parallel and an open belt drive cannot be used because of the short angle of contact on the smaller pulley, a belt drive with an idler pulley is employed.

Idler pulleys are used to obtain required belt tension, change the direction of the belt's motion as well as to increase velocity ratio.





4. Compound belt drive:

- This arrangement is used when power is transmitted on more than one shaft.
- Used when power is transmitted from one shaft to another through a number of pulleys.

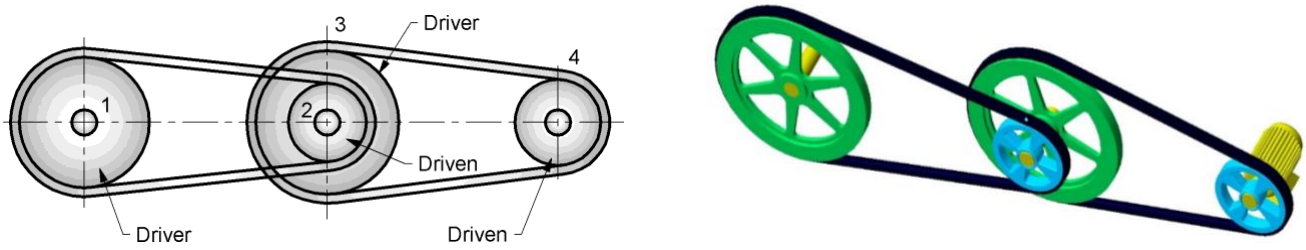


Fig. 6.34.4: Compound belt drive

6.35 Features of V-belt drive

Conditions under which 'V' belt drive is selected are as follows:

1. Greater amount of power is to be transmitted.
2. Small center distance between shafts
3. Requirement of positive drive
4. High velocity ratio is required (up to 10)

Advantages of V-belts drive:

1. V-belts may be used for speed ratio as high at 10 : 1 and belt speeds upto 2100 m/ min.
2. Power output can be increased by use of multiple belts.
3. Increase of multiple belt drive if one belt fails, the machine doesn't come to stop.
4. The Gripping action results in lower belt tension.

Disadvantages of V-Belt:

1. V-belt cannot be used with large central distance.
2. The V-belt are not durable as Flat belt.
3. The construction of pulley for V-belt is more complicated.
4. The belt-life is greatly influenced with temperature change mismatching belt length and improper belt tension.

Advantages of the V-belt Drive Over Flat Belt Drive:

1. The V-belt drive gives compactness due to the small distance between the centers of pulleys.
2. The drive is positive, because the slip between the belt and the pulley groove is negligible.
3. Since the V-belts are made endless and there is no joint trouble, therefore the drive is smooth.
4. It provides longer life, 3 to 5 years.
5. It can be easily installed and removed.
6. The operation of the belt and pulley is quiet.
7. The belts have the ability to cushion the shock when machines are started.
8. The high velocity ratio (maximum 10) may be obtained.
9. The wedging action of the belt in the groove gives high value of limiting ratio of tensions.
10. Therefore, the power transmitted by V-belts is more than flat belts for the same coefficient of friction, arc of contact and allowable tension in the belts.

Applications of flat belt:

(i) Floor mill (ii) Textile Industry (iii) Spinning Machine (iv) Weaving machines

Application of Vee belt

(i) Centre lathe
(ii) Radial drilling machine
(iii) Radiators

6.36 COMPARISION BETWEEN FLAT BELT AND V BELT

Sr. No.	Factor	Flat Belt	Vee Belt
1.	Cross sectional area	Rectangular	Trapezoidal
2.	Area of application	They are used when the two pulleys are not more than 8 m apart.	They are used when the two pulleys are 2-3 m apart.
3.	Efficiency	Low (due to slippage) as compared to Vee Belt	More as compared to flat Belt.
4.	Joint	They have a joint	They are endless
5.	Construction of pulley	Simple	Complicated
6.	Cost	Cheaper	Costlier
7.	Precise alignment	Not required	Required
8.	Constant velocity ratio	Cannot be obtained	Can be obtained
9.	Power transmitting capacity	Less as compared to Vee belt	More as compared to flat belt
10.	Speed reduction ratio	Less	More
11.	Operation	Noisy as compared to Vee belt	Quiet as compared to flat belt

6.37 WASHING MACHINE:

Washing machine is one of the most important technologies that almost every one of us use in our daily life. Without exerting any physical effort, washing machines are used to wash numerous types of clothing. You may wash your clothes automatically in the washing machine without having to keep an eye on it.

Components of Washing Machine:

Motor drive:
It converts electrical energy into mechanical energy. According to the washing machine's operating system, a motor is used to move the drum's agitator in top-loading machines and the drum or tub in front-loading ones.

Agitator:
The moving component of the washing machine, called the agitator, is situated in the middle of the drum and is moved back and forth by the motor. They are made to move the clothing around so that the detergent can be distributed evenly, and the clothes can be made clean and organized.

Drum/tub:
A drum is simply a container in which we place our clothing for thorough washing. Water can enter and exit through gaps in the inner drum's construction. With no holes, the outer drum serves as a reservoir for the inner drum's water during operation.

Sensors/Switches:
A sensor is simply a device that measures physical parameters such as temperature, pressure, level, waves, etc. and sends an immediate report of the information to the main control.

Drain Pipe:
The outlet pipe used to remove the drum's dirty water is called a drain pipe.

Drain pump:
Pumps are used in washing machines to remove the water from the drum while it is being drained. It is at the base of the machine. During wash cycles, it also moves the water around the tub.

Control Panel:
The control panel is the brain of the washing machine like CPU, the brain of the computer. It instructs the machine to operate after we set the programs.

Working Principle of Washing Machine:

- As the machine starts, A water flow into the drum is made possible by opening the inlet valves. Collection of powder or liquid is done as it moves through the detergent tray.
- Washing machines operate in two primary cycles. These are the wash cycle and the rinse cycle.
- During the wash cycle, the moment of the agitator causes a circulatory motion of water, producing a centrifugal force that pushes water outwardbetween the paddles towards the edge of the tub.
- During Rinse cycle, your clothing is rewashed in clean water when the washing machine is filled with clean water after the filthy, soapy water has been drained. Centrifugal force is used to quickly spin your clothing after they have been entirely drained of all water.

In rinse and spin cycle, it runs with no detergent and just rinses the clothes and spins the moisture out.

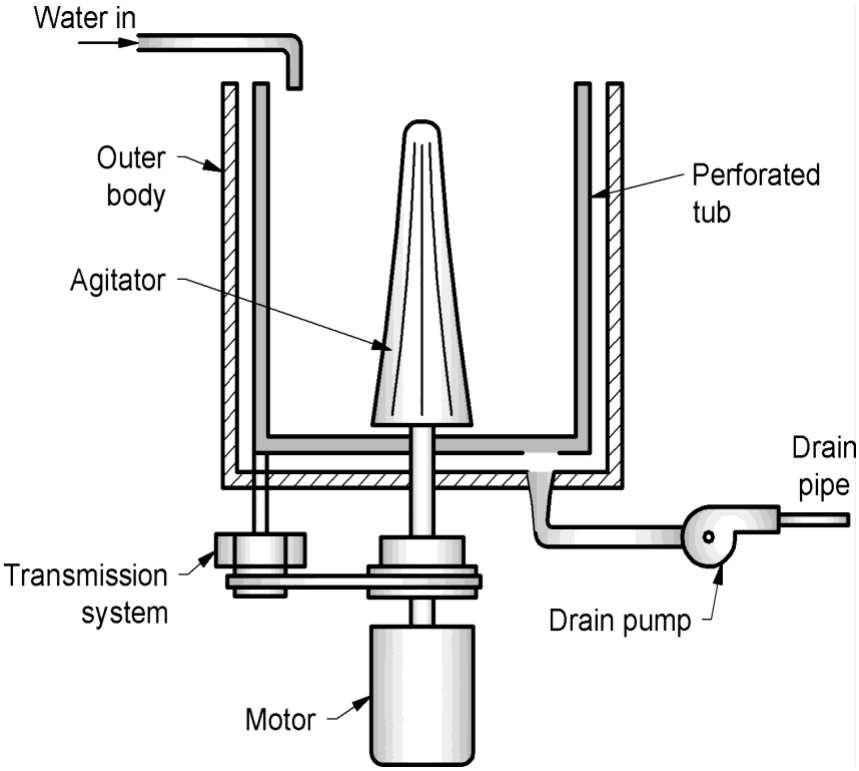
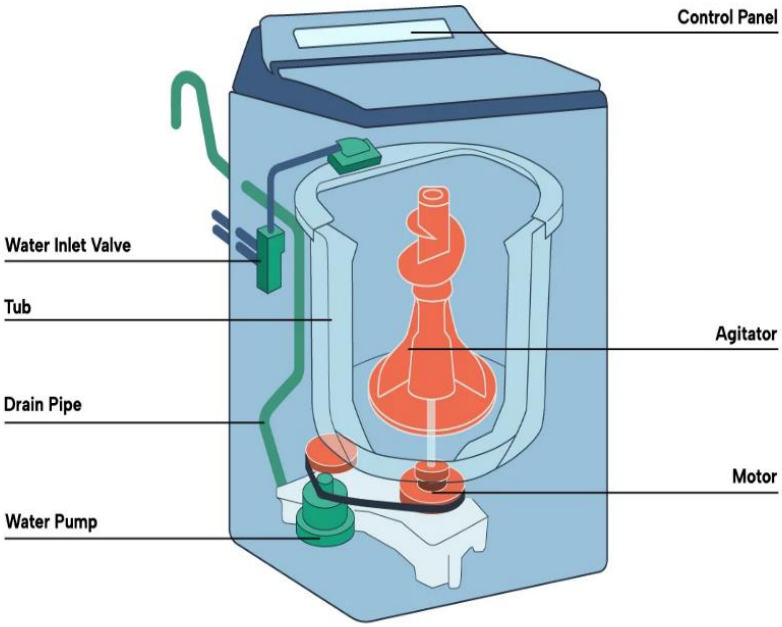


Fig. 6.37 Belt drive mechanism in Washing Machine



6.38 PHOTOCOPIER:

Construction & Simple Working Principle:

1. Place the paper you wish to duplicate upside down on the glass.
2. The document is illuminated with an intense light. In comparison to the black, inked parts, far more light reflects off the white (absence of ink) portions.
3. The page createsan “electrical shadow" on the photoconductor. A spinning conveyor belt covered in a substance known as selenium serves as the photoconductor in a photocopy.
4. The electrical shadow moves around with the belt as it revolves.
5. The belt gets powdered ink dust on it from an ink drum that touches it (toner).
6. Due of the electrical charge applied to the toner, it adheres to the electrical shadow and creates an inked image of the original page on the belt.
7. A sheet of paper is fed up with the first belt on a conveyor belt from a hopper on the opposite side of the copier. A significant electrical charge is applied to the paper as it moves.
8. A strong charge on the paper pulls charged toner particles away from the upper belt when it moves in proximity. From the belt to the paper, the image is quickly transferred.
9. Two hot rollers pass across the inked paper (the fuser unit). The toner particles are firmly bonded to the paper by the rollers' pressure and heat.
10. Out of the side of the copier, the last copy is visible. The paper has retained its warmth thanks to the fuser unit. It might still contain enough static electricity for it to adhere to your pullover.

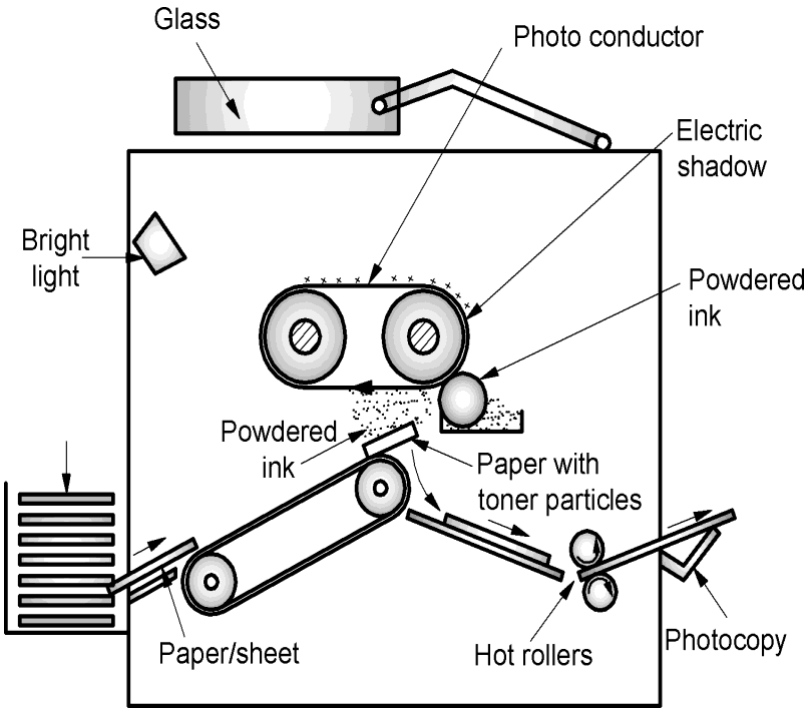
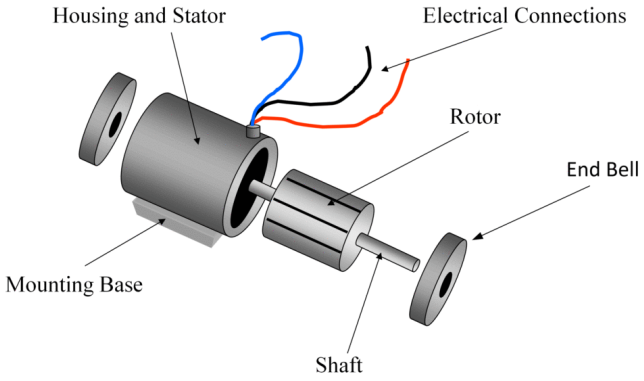


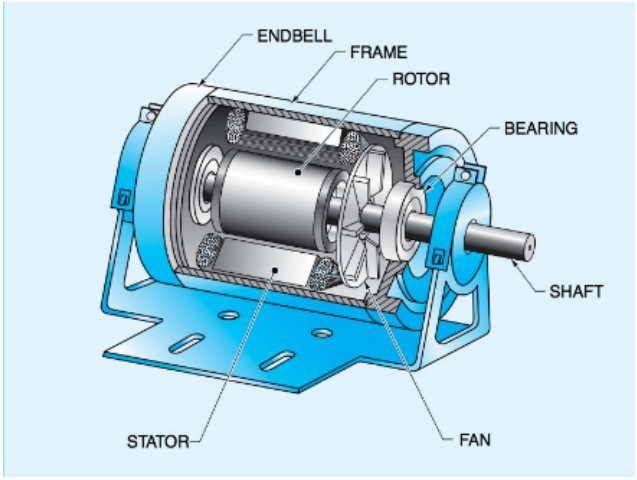
Fig. 6.38- Belt drive in Photocopier

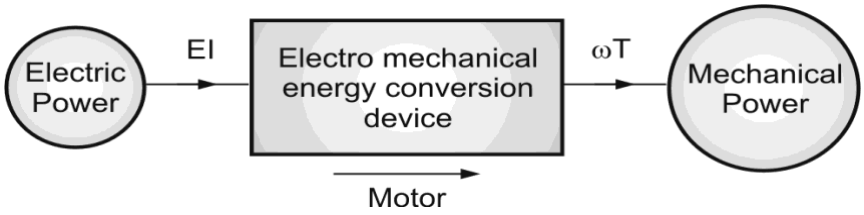
6.39 MOTOR:

A machine that uses electricity to transform electrical energy into mechanical energy is known as an electric motor. Most electric motors produce force in the form of torque applied to the motor shaft by interacting their magnetic field with electric current in a wire winding.

The two main types of motors are AC motors and DC motors. During start, AC motors use less power and have variable speed capabilities. However, because they are simpler to install and have a lower starting cost than AC motors, DC motors are more commonly used.







6.40 FAN:

The ceiling fan operates on the principle of electromagnetic induction. Electrical energy is transformed into mechanical energy by the induction motor of ceiling fan. A single-phase alternating current source of 250 volts is needed for the motor.

The induction motor's coils can be activated to produce the rotating magnetic field that the ceiling fan needs to operate. The primary problem is that a single-phase induction motor is only capable of producing a pulsating magnetic field in the winding, not a spinning magnetic field.

As a result, for the motor to create angle variations, a capacitor is needed.

6.41 EXHAUST FAN:

Exhaust fans function by pulling heated air, odors, moisture, and dust from the room and expelling them outside.

All fans operate on this same principle, but an exhaust fan's primary function is to draw hot air from your home and expel it from the opposite side.

The exhaust fan blades are fastened to a hub and the fans are oriented such that when they rotate, they pull air in from one side and expel it out of the other.

Benefits of Exhaust Fan:

1. Cools and dehumidifies indoor spaces.
2. Eliminates minute amounts of dust.
3. Clears the air of odors and smells in rooms.
4. Assist in preventing the growth of fungi.
5. Keep the spaces cool.
6. Convenient to clean and maintain.

6.42 CHAIN DRIVE

6.42.1 Introduction to Chain Drive

- We have seen in belt drive and rope drive that slipping may occure.
- In order to avoid slipping steel chains are used. The chains are made up of rigid links which are hinged together in order to provide necessary flexibility for warping around the driving and driven wheels.
- The wheels have projecting teeth and fit into the corresponding recesses in the links of the chain as shown in Fig. 6.42.1.

Fig. 6.42.1: Sprocket and chain

- The wheel and the chain are thus constrained to move together without slipping and ensures perfect velocity ratio.
- The toothed wheels are known as sprocket wheels or simply sprockets. These wheels resemble to spur gears.
- Transmit motion and power from one shaft to another, when the distance between the centre is the shaft is short such as in bicycle, motorcycles, agricultural machinery, and road rollers etc.

  The chain is basically classified into three group according to their use.

Types of Chain:

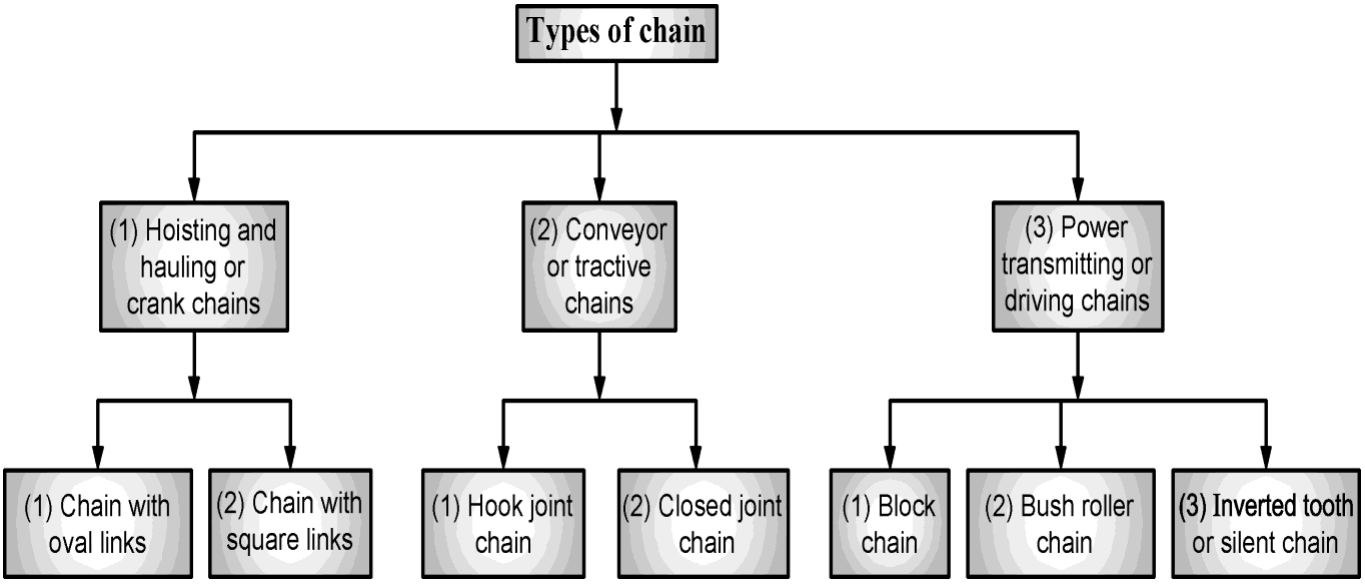


Fig. 6.42.2

(A) Hoisting and Hauling chains

These chains are used for hoisting and hauling purposes.

The hoisting and hauling chains are of the follows two types.

(1) Chain with oval links

- This type of chain is oval shape as shown in Fig. 6.15.3.
- The joint of each link is welded.

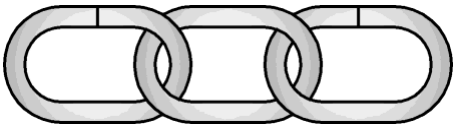


Fig. 6.42.3: Chain with oval links

- Used for low speeds such as in chain hoists and anchors free machine works.

(2) Chain with square links

- The links of this type of chain are square shape as shown in Fig. 6.42.4.
- Chain are used in hoists, cranes, dredges.

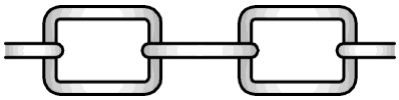


Fig. 6.42.4: Chain with square links

(B) Conveyor chains

- Chains are used for elevating and conveying the material continuously. The conveyor chains are of the following types.
  (1) Detachable or hook joint type chain (Refer Fig. 6.42.5)
  (2) Closed joint type chains. (Refer Fig. 6.42.6)
- Chains are usually made of malleable cast iron.
- The conveyors chain run at slow speeds of about 3 to 12 km.p.h

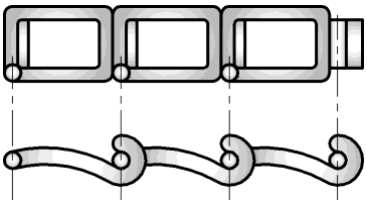


Fig. 6.42.5: Detachable hook joint type chain

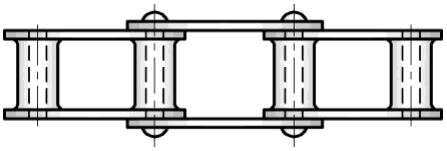


Fig. 6.42.6: Closed joint type chain

(C) Power transmission chains

- The chains are used for transmission of power when the distance between the centres of shaft is too short.
- Efficient lubrication.

1. Blocks chain (Refer Fig. 6.42.7)

- Blocks chain known as bush chain development in the power transmission.
- It produces Noise when approaching or leaving the teeth of the sprocket because of rubbing between the teeth and the links.
- Such type of chains are used to some extent as conveyor chain at low speed.

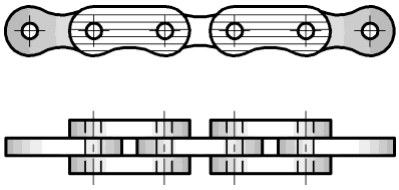


Fig. 6.42.7: Block chain

2. **Bush Roller chain** (Refer Fig. 6.42.8)
   - Consists of outer plates or pins link plates inner plates or Roller links plates, pins, bushes and rollers.
   - A pin passes through the bush which is secured in the holes of the roller between the two sides of chain.
   - It is extremely strong and simple in construction.
   - Given good service under server conditioning.
   - This chain may be where there is a little lubrication.

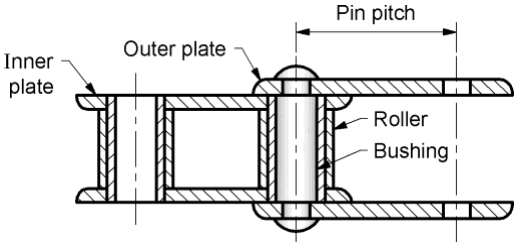
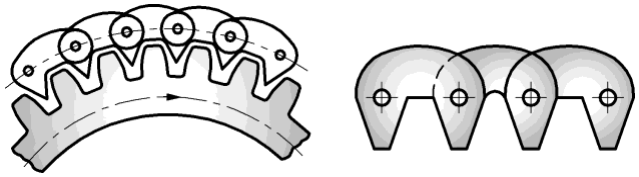


Fig. 6.42.8: Roller chain

3. **Inverted tooth chain or silent chain**
   - It is designed to eliminate the evil effects caused by stretching and to produce Noiseless running.
   - It gives smooth and durable service when properly lubricated.
   - It is defined as the angular velocity of the driven to the any velocity of the driver sprocket.



(1D23)Fig. 6.15.9

   - The chain is wrapped round the sprocket in the form of a pitch polygon.

The different types of chains used in power transmission are:

• Roller chain	• Silent chain	• Leaf Chain	• Flat-top Chain	• Engineering Steel Chain.

Parameters for Selection of Chain Drive for Power Transmission

1. Type of application.
2. Shock load.
3. Source of power: motor type; rated power (kW); moment of inertia, ; rated torque at driving speed; starting torque; and stopping torque.
4. Drive sprocket rpm and shaft diameter.
5. Driven sprocket rpm and shaft diameter.
6. Center distance between sprockets.
7. Noise constraints.
8. Lubrication (possible or not).

Merits and Demerits of Chain Drive

Advantages (Merits)

1. Constant velocity ratio is obtained due to absence of slip.
2. The chain drive gives less load on the shaft.
3. These are compact than belt or rope drive.
4. Severalshafts can be driven in the same or in opposite direction by chain drive.

Disadvantages (Demerits)

1. The chain drive create noise compared to belt and rope drive.
2. The chain drive requires accurate mounting and proper lubrication and maintenance.

Application

1. Two-wheel drives in Automobiles
2. Military vehicles

Advantages of Chain Drive Over Belt Drive

1. As no slip takes place during chain drive, hence perfect velocity ratio is obtained.
2. Since the chains are made of metal, therefore they occupy less space in width than a belt or rope drive.
3. The chain drives may be used when the distance between the shafts is less.
4. The chain drive gives a high transmission efficiency (upto 98 per cent).
5. The chain drive gives less load on the shafts.
6. The chain drive has the ability of transmitting motion to several shafts by one chain only.

Disadvantages

1. The production cost of chains is relatively high.
2. The chain drive needs accurate mounting and careful maintenance.
3. The chain drive has velocity fluctuations especially when unduly stretched.

Application of Chain drive - Bicycle:

6.43 BICYCLE

A bicycle, often known as a bike, is a vehicle used for transportation. Most bicycles feature a frame and two wheels. Two pedals, a seat, and steering handlebars are all part of the frame. Bicycles are used by millions of people around the world for joy, exercise, and sport.

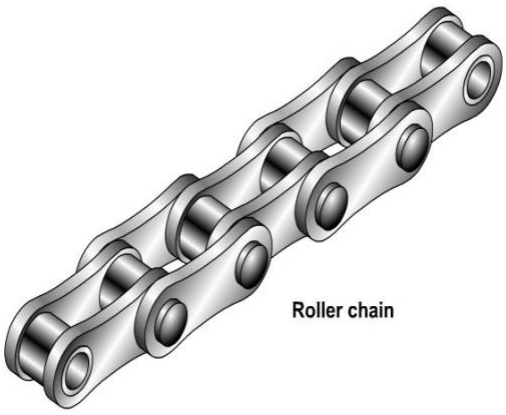
Basic Working Principle:

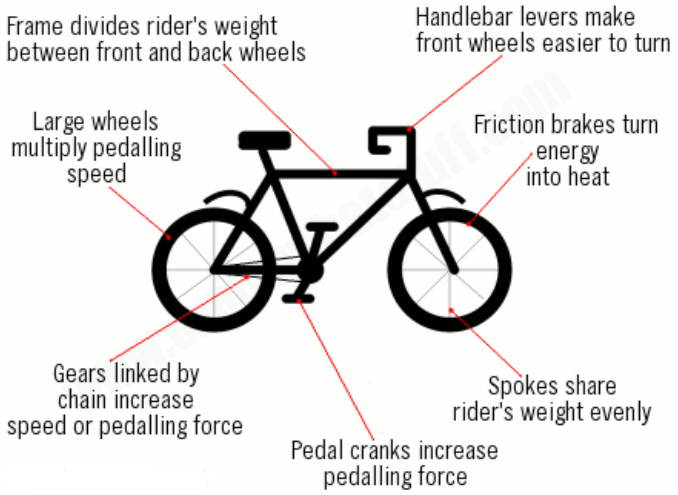
Every bike must be sturdy enough to handle the weight of the user and the weights it can encounter during various types of handling. Therefore, compared to a bike built of steel tubing, an aluminum bike would use tubing with a bigger diameter and/or thicker walls.

Mostof the bicycle wheels have a diameter of over 45-50cm (18-20 inches), making them taller than most automobile wheels. When you turn the wheels at the axle, the taller the wheels are, the faster you go.

Two sprockets are connected by a flexible medium known as a chain. The driving member is driving sprocket is the Driven sprocket is the other sprocket. Through the chain, force and motion may be transferred from one shaft to another via the sprockets.

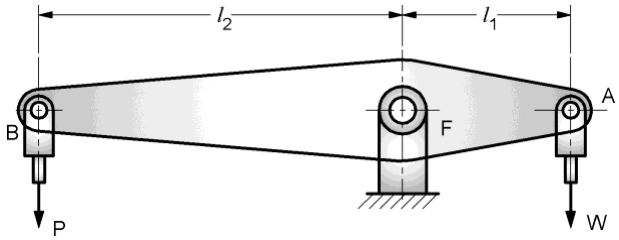
No matter how quickly you go, you eventually have to stop. Friction is how bicycle brake's function. Many motorcycles still utilize the conventional caliper-operated rim brakes with shoes, even though some now have disc brakes (like the ones used in cars), with separate brake discs mounted to the wheels.





6.44 LEVER MECHANISM

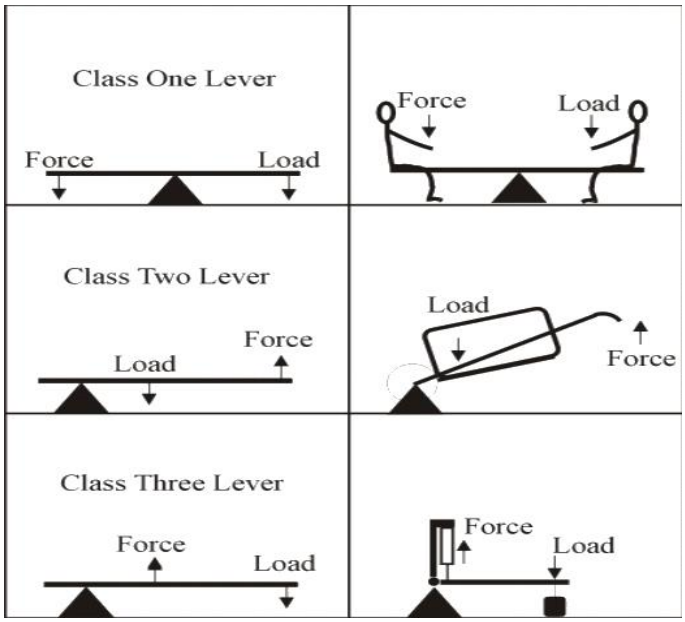
A rigid rod that revolves around a pivot (or fulcrum) point is called a lever. When one end moves downward, the other end moves higher. A lever can double the force exerted or the distance across which the force is applied, depending on where the pivot point lies.

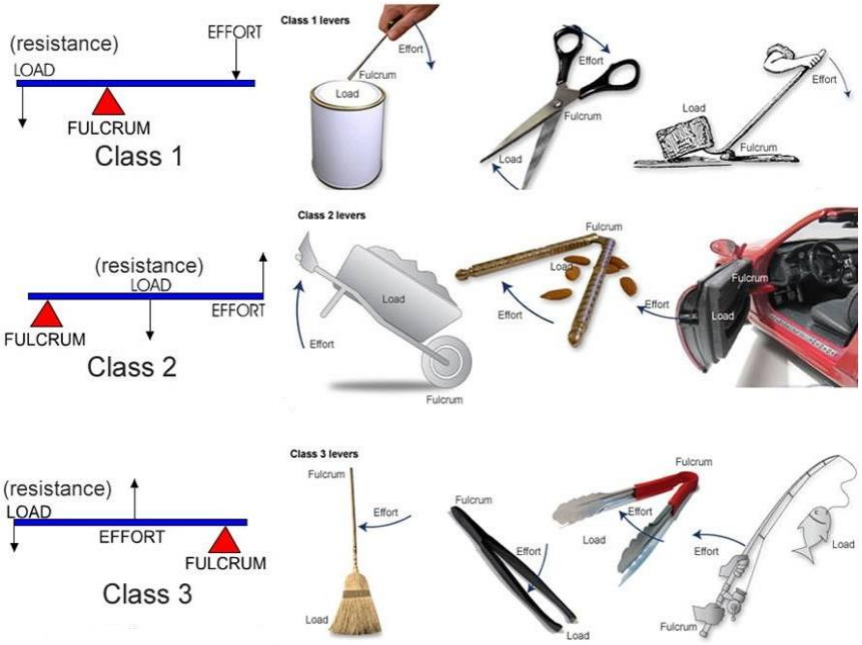


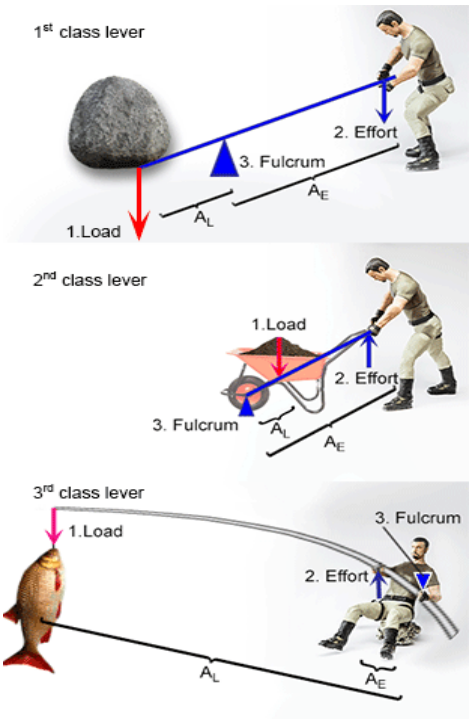
The fulcrum of class 1 levers is situated halfway between the weight and the effort. Examples include a seesaw, some scissors, some pliers, and a typical beam balance.

The fulcrum is located at the end of class 2 levers. In other words, the weight is now situated between the fulcrum and the effort. Wheelbarrows and bottle openers are two examples.

The fulcrum is also located at one end of class 3 levers. The effort, however, is thus situated between the load and the fulcrum. Examples include a knife or a shovel, where the elbow serves as the fulcrum







Application of Lever:

6.44 BRAKE PEDAL

Brakes are installed on the wheels of the vehicle to help it slow down the motion or completely stopping the vehicle. The car may be stopped quickly and simply by using the brake pushing the brake lever or pedal.

Brakes typically employ friction between two surfaces to turn the vehicle's kinetic energy into heat, which then causes the vehicle to stop.

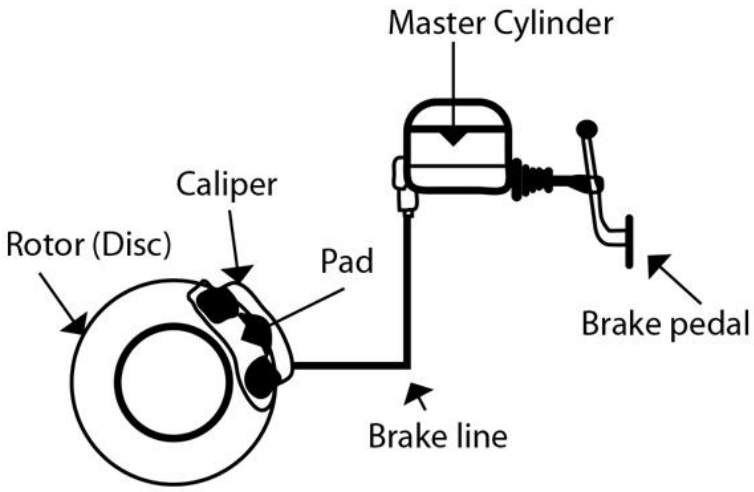


Fig 6.44 – Lever operated Brake pedal

Basic Working Principle:

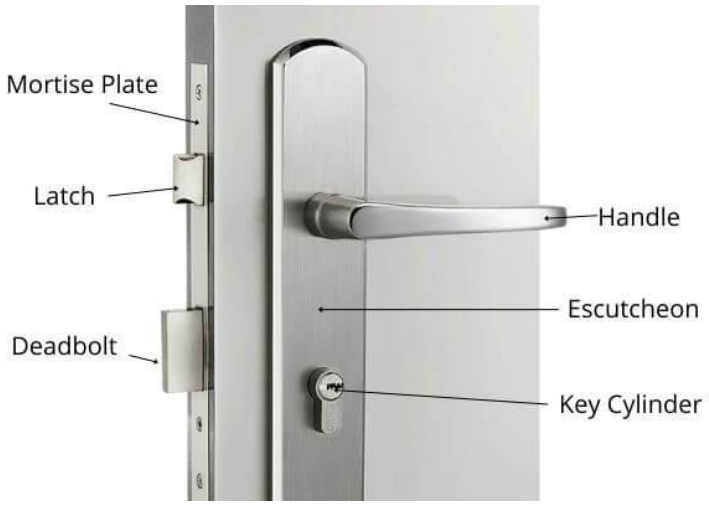
1. The braking system of your automobile is composed of a number of components, including the master cylinder, brake lines and hoses, brake pads, rotors, the brake pedal, the automated hydraulic control system (if your car has ABS), and brake fluid.
2. To apply the brakes, one need to press the brake pedal by foot which is further connected by push rod that pushes the Piston in cylinder fitted with brake fluid.
3. The brake system delivers a measured amount of hydraulic force to the brake pads (either drum or disc) in order to apply pressure to the brakes drum or rotor and slow the rotation of the tires.
4. The more pressure is applied, the more force will be applied, which will absorb the energy of the rotating tyres. the vitality.
5. It's critical to make sure your brakes are properly vented because the energy is released as heat. Stopping distances increase as brakes deteriorate.

6.45 DOOR LATCH

The latch is the spring-loaded metal component of the mechanism that extends from the door. This guarantees that the door is fastened, keeping it shut. The spring-loaded latch retracts from its rest position and moves within the door as the lever is lowered.

Main components and their purpose:

Mortise plates
These plates strengthen the door panel, deadbolts, and latches, reducing the likelihood of a forced entry.

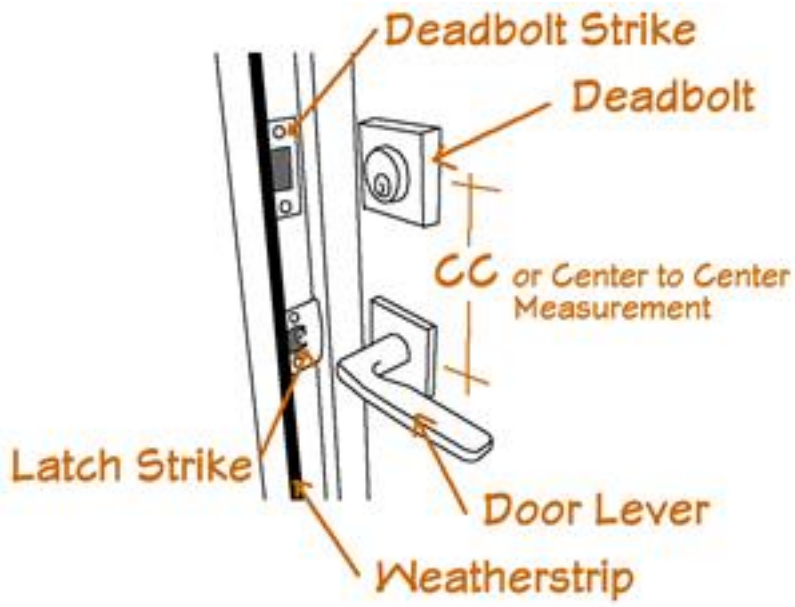


Escutcheon
Escutcheons, which are decorative plates, are found encircling handles, thumb turns, and key cylinders. They are intended to prevent dents and scratches from occurring on the door panel surface.

Handle/Lever:
A handle or lever is the component of door hardware that is used to unlatch the door panel. It pulls the deadbolt to open the door and push it to close.

Deadbolt:

A deadbolt, which is a shaft that extends from the edge of the door panel and into the door frame to secure the panel in place, works similarly to a latch.



Latch:
A door latch is a shaft that extends from a door panel's edge and into the door frame to hold the panel firmly in place. The latch retracts when the handle is turned, allowing the door to be opened.

Weather-strip:
In order to prevent light and air leaks while the door is closed, the weather stripping is typically attached to the doorframe. The components are thoughtfully proportioned and positioned to seal any gaps that could otherwise exist when your door is closed.

6.46 VALVE

A valve is a mechanical device that regulates the flow of fluid (such as liquid, gas, etc.) through a channel, pipeline, or other enclosure.

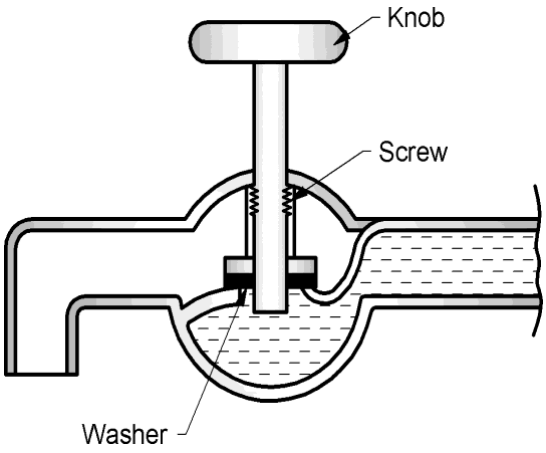
Application of valves:

Residential plumbing systems
Petrochemical, Refining industry
Heating, ventilating & air-conditioning (HVAC)
Power plants
Firefighting system

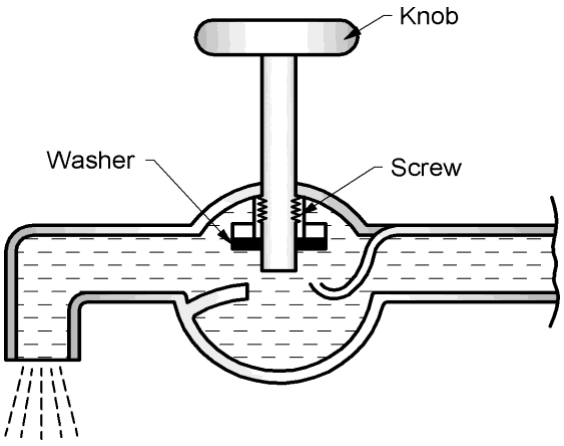
6.47 WATER TAP

Water tap:

- The flow of water is controlled by turning or moving the tap knob/handle which is connected to the spindle.
- The water chamber opens and closes as a result of the spindle's movement, which also moves the tap valve up or down.
- When you want water all you need to do is turn the handle anticlockwise which unscrews an internal valve and starts the flow of the water.
- When you want to shut the flow of water, you just need to turn the knob in clockwise direction screwing up and closing the flow of water.
- From connection pipes that carry water from the water supply to a tap, the chamber is supplied with cold and/or hot water.



Water tap closed position



Water tap open position

Important Questions:

1. What is input, Output and efficiency of machine?
2. What is pump? Explain working principle of Centrifugal Pump.
3. With neat sketch, explain working of reciprocating pump.
4. Explain with block diagram water pump set for overhead tanks.
5. Explain with sketch how water purifier works?
6. Describe working of single acting reciprocating air compressor with neat sketch.
7. Explain vapor compression cycle used in Household refrigerator.
8. With neat sketch, explain working principle of Split AC.
9. Explain working of water cooler with block diagram.
10. Explain how vacuum cleaner works?
11. Describe solar water heater with sketch. Give its applications.
12. How electric energy is used in Electric geyser? Explain.
13. With sketch, explain basic working of Electric Iron.
14. Explain different types of belt drive. Give their applications.
15. Differentiate flat belt and V belt.
16. Describe different types of belt drives with neat sketch.
17. Draw a block diagram of Photocopier. Explain the purpose of belt drive in it.
18. What is chain drive? State advantages, disadvantages and applications of chain drive.
19. Explain spur gear and bevel gear with sketch.
20. What is rack and pinion gear arrangement? Explain advantages and disadvantages of gear drive over belt drive.
21. Explain how blower fan operates in kitchen chimney?
22. What is spring? Describe its use in door closer with sketch.
23. What is gear drive? How it functions in wall clock.
24. With sketch, explain how printer works?
25. What are the applications of valve? Explain water tap with sketch.