[Notes]

(FUNDAMENTAL OF MECHANICAL ENGINEERING BME-101/BME-201)

UNIT-IV

Fluid mechanics is that branch of science which deals with the behavior of the fluids at rest as well as in motion. In general, the scope of fluid mechanics is very wide which includes the study of all liquids and gases.

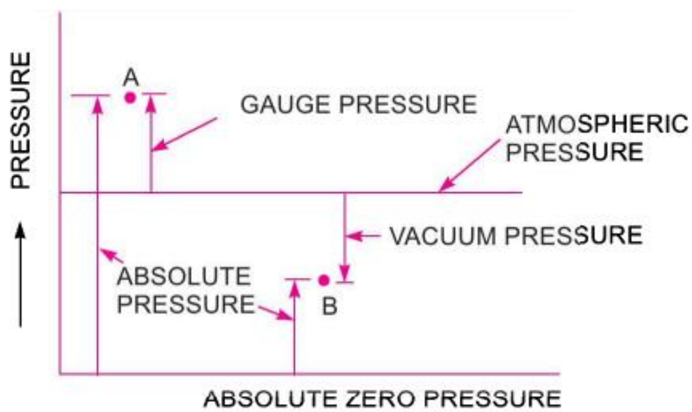
It has applications in **mechanical, civil, chemical, aeronautical engineering and biomedical engineering, biology** etc.

Basic Properties of fluid are as following:

- Pressure
- Density
- Specific Weight
- Specific Gravity
- Dynamic Viscosity
- Kinematic Viscosity

Pressure is defined as normal force per unit area. p =F/A

It is a scalar quantity. Units of Pressure: N/m^2, Pascal (Pa) ; (1 Pa = 1 N/m^2), Atm (1 atm = 101325 Pa = 101.325 kPa)



ABSOLUTE PRESSURE:

It is the zero reference to a perfect vacuum, which exists in the air free space of the universe.
Absolute pressure is the sum of gauge pressure and atmospheric pressure.

P(abs) = **P**(gauge) + **P**(atm)

2. GAUGE PRESSURE:

It is the pressure, zero referenced against ambient pressure. Gauge pressure is positive for pressures above the atmosphere and negative for pressures below it.

P(gauge) = **P**(abs) – **P**(atm)

3. ATMOSPHERIC PRESSURE:

It is the pressure exerted by the weight of the atmosphere. It is basically pressured around you i.e.ambient pressure.

4. VACUUM PRESSURE:

It is the pressure below atmospheric pressure is measured by vacuum gauges. It indicates the difference between atmospheric pressure and absolute pressure.

P(vac) = **P**(atm) – **P**(abs)

Density is defined as mass per unit volume of the substance.

$$\rho = m/V$$

Units of density: Kg/m^3 ; g/cm^3 or g/cc ;

For example

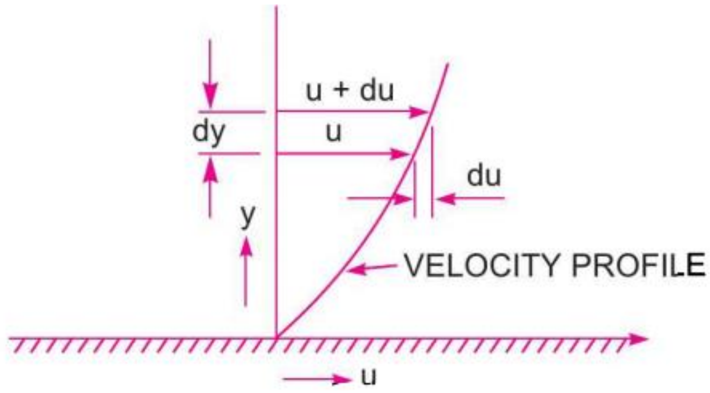
$\rho_{\text{water}} = 1000\ kg/m^3$ $\rho_{\text{air}} = 1.2\ kg/m^3$ $\rho_{\text{steel}} = 7850\ kg/m^3$

Specific Weight or Weight Density is defined as weight per unit volume.
$w = mg/V = \rho g$
Unit of specific weight is N/m^3
Specific Gravity(S) is defined as the density of the fluid w.r.t. the density of standard fluid.

Specific Gravity(S) = density of fluid/density of standard fluid

Note: For liquid, standard fluid is water (at 4°C (39.2°F), 1 atm, 1000 kg/m^3). For gases, standard fluid is Air.

Viscosity- Two adjacent layers of the fluid resist the motion of each other such a fundamental property of the fluid is known as viscosity or dynamic viscosity. Therefore, the frictional force between the adjacent layers is known as viscous shear force.



Newton's law of viscosity: According to Newton's law of viscosity "Shear stress between the layers of fluid is directly proportional to rate of shear deformation or rate of shear strain.

$$\tau \propto (du/dy)$$

$$\text{so, } \tau = \mu(du/dy)$$

Where μ is proportionality constant (property of fluid) which is known as viscosity or dynamic viscosity. Unit of viscosity is poise, $N\text{-}s/m^2$.

Note: How the temperature effect viscosity:

With an increase in temperature, there is typically an increase in the molecular interchange as molecules move faster in higher temperatures.

The gas viscosity will increase with temperature. According to the kinetic theory of gases, viscosity should be proportional to the square root of the absolute temperature, in practice, it increases more rapidly.

In a liquid there will be molecular interchange similar to those developed in a gas, but there are additional substantial attractive, cohesive forces between the molecules of a liquid (which are much closer together than those of a gas). Both cohesion and molecular interchange contribute to liquid viscosity. The impact of increasing the temperature of a liquid is to reduce the cohesive forces while simultaneously increasing the rate of molecular interchange.

The former effect causes a decrease in the shear stress while the latter causes it to increase. The result is that liquids show a reduction in viscosity with increasing temperature. With high temperatures, viscosity increases in gases and decreases in liquids, the drag force will do the same.

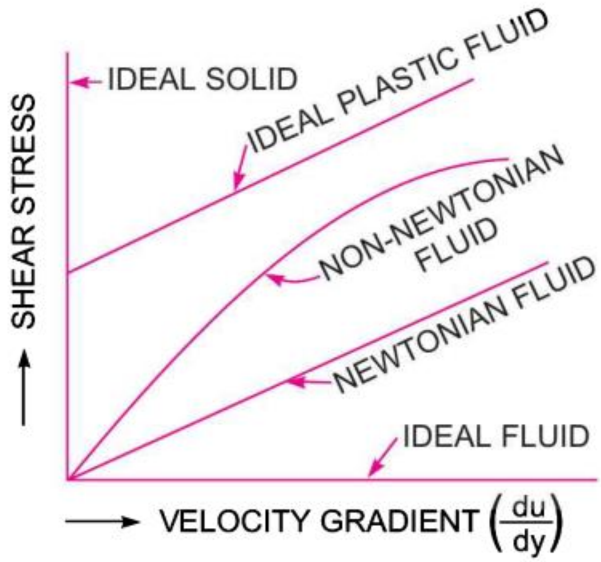
Viscosity of liquid decreases with increase in temperature. [if T↑ then cohesion ↓]
Viscosity of gases increases with increase in temperature. [if T↑ then randomness↑]

kinematic viscosity: Ratio of dynamic Viscosity and density is called Kinematic Viscosity.

$$\nu \text{ (nu)} = \mu / \rho$$

Units of kinematics viscosity is Stoke or m^2/s

Various types of fluid



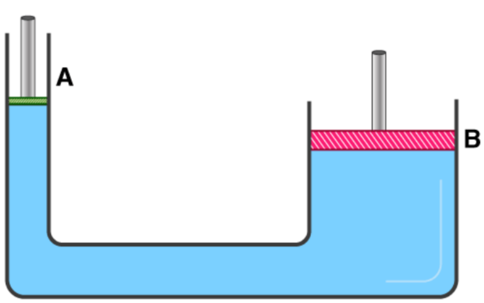
Newtonian Fluid - All the fluids which obey Newton's law of viscosity are known as Newtonian fluids
Non-Newtonian Fluid - The fluids which do not follow Newton's law of viscosity are known as Non-Newtonian Fluid.
Ideal Fluid- Incompressible fluid having zero viscosity is called ideal fluid (Ʈ = 0).
Real Fluid- A fluid, which possessive viscosity, is known as real fluid.

Pascal's law:

Pascal's Law states that the pressure exerted anywhere in a confined liquid is transmitted equally and undiminished in all directions throughout the liquid.

- Consider the image given below. The column is filled with water and the ends of each column A and B have been blocked by a piston. If piston A is pressed, what do you think will happen to piston B? Piston B is going to rise up.

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$



$$\frac{F_2}{F_1} = \frac{A_2}{A_1}$$

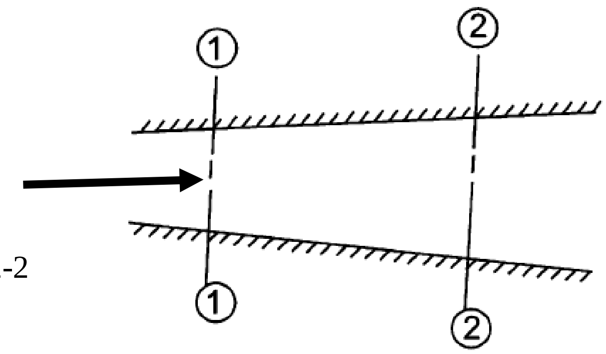
Applications of Pascal's law are

Hydraulic lift
Hydraulic Jacks
Hydraulic brakes
Hydraulic pumps

Continuity equation: This equation is based on the principle of conservation of mass. The quantity of fluid per second is constant at all the cross sections through the pipe.

Flow Rate → Volume flow rate= liter per second= area*length/second (Liter= volume)

Derive an expression for continuity equation



Consider two cross sections as shown in figure:
Let V_1 = Average velocity at cross-section 1-1
ρ_1 = density at section 1-1
A_1 = Area of pipe at section 1-1
and V_2, ρ_2, A_2 are corresponding values at section 2-2
Rate of flow at section at 1-1 = $\rho_1 A_1 V_1$
Rate of flow at section at 2-2 = $\rho_2 A_2 V_2$
According to law of conservation of mass:
Rate of flow at section at 1-1 = Rate of flow at section at 2-2

$$\boxed{Q = \rho_1 A_1 V_1 = \rho_2 A_2 V_2 = \text{Constant}}$$

This Continuity Equation is applicable for the compressible as well as In- compressible fluids.
If the fluid is In-compressible, i.e., water then $\rho_1 = \rho_2$ and continuity equation becomes:

$$\boxed{Q = A_1 V_1 = A_2 V_2 = \text{Constant}}$$

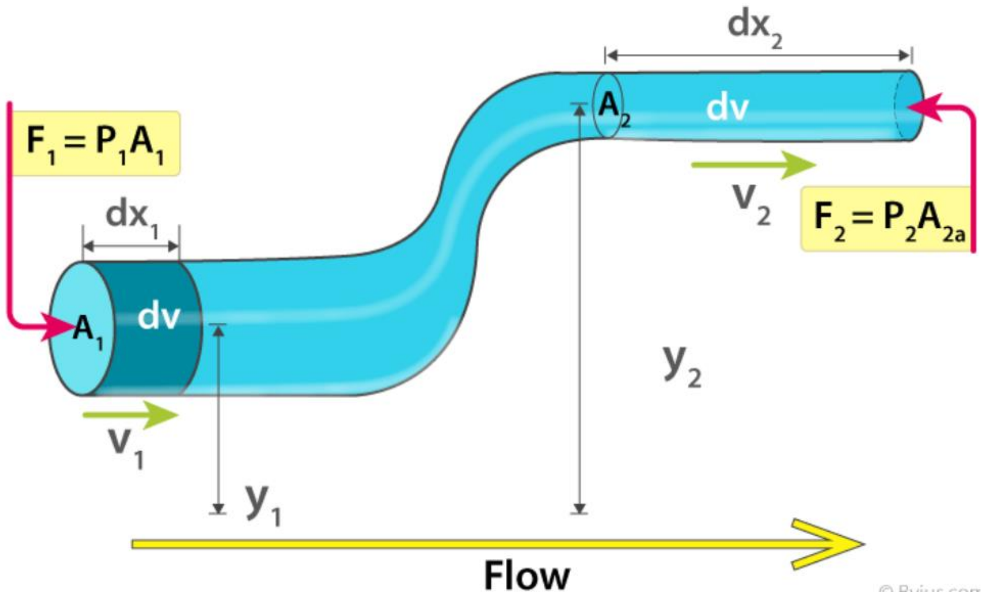
State the Bernoulli's Theorem: According to Bernoulli's theorem the sum of pressure energy, potential energy and kinetic energy per unit mass is constant at all cross-section in the streamline flow of an ideal liquid.

Bernoulli's Equation Derivation:

The following assumptions are made in the derivation of Bernoulli's equation:

1. The fluid is ideal, i.e., viscosity is zero
2. The flow is incompressible
3. The flow is irrotational
4. The flow is steady

Consider a pipe with varying diameter and height through which an incompressible fluid is flowing. The relationship between the areas of cross-sections A, the flow speed v, height from the ground y, and pressure p at two different points 1 and 2 is given in the figure below



Therefore, the work done on the fluid is given as:

$dW = F_1dx_1 – F_2dx_2$

$dW = p_1A_1dx_1 – p_2A_2dx_2$

$dW = p_1dV – p_2dV = (p_1 – p_2)dV$

The change in potential energy is given as:

$dU = mgy_2 – mgy_1 = \rho dVg(y_2 – y_1)$

The change in kinetic energy of the fluid is given as:

$$dK = \frac{1}{2}m_2v_2^2 - \frac{1}{2}m_1v_1^2 = \frac{1}{2}\rho dV(v_2^2 - v_1^2)$$

Therefore, the energy equation is given as:

$dW = dK + dU$

$$(p_1 - p_2)dV = \frac{1}{2}\rho dV\left(v_2^2 - v_1^2\right) + \rho dVg(y_2 - y_1)$$

$$(p_1 - p_2) = \frac{1}{2}\rho\left(v_2^2 - v_1^2\right) + \rho g(y_2 - y_1)$$

Rearranging the above equation, we get

$$p_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = p_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

$$\frac{p}{\rho g}+\frac{v^2}{2g}+z=\text{constant}$$

Where;

$\frac{p}{\rho g}$ = pressure energy per unit weight of fluid or pressure head.

$v^2/2g$ = kinetic energy per unit weight or kinetic head.

z = potential energy per unit weight or potential head.

Application of Bernoulli's Equation: There are so many applications of Bernoulli's equation, but three of are very important as:

1. **Verturi meter:** This device is used for measuring flow through pipe.
2. **Orifice meter:** This device is also used for measuring flow through pipe.
3. **Pitot Tube:** This device is used for velocity of flow through pipe.

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1. **Calculate the specific weight, density and specific gravity of one litre of liquid which weighs 7N.**

Ans:

$$\text{Volume} = 1 \text{ litre} = \frac{1}{1000}\text{ m}^3 \quad \left(\because\ 1 \text{ litre} = \frac{1}{1000}\text{ m}^3 \text{ or } 1 \text{ litre} = 1000 \text{ cm}^3\right)$$

$$\text{Weight} = 7 \text{ N}$$

(*i*) Specific weight (w) $= \frac{\text{Weight}}{\text{Volume}} = \frac{7\text{ N}}{\left(\frac{1}{1000}\right)\text{m}^3} = \mathbf{7000\ N/m^3.\ Ans.}$

(*ii*) Density (ρ) $= \frac{w}{g} = \frac{7000}{9.81}\text{ kg/m}^3 = \mathbf{713.5\ kg/m^3.\ Ans.}$

(*iii*) Specific gravity $= \frac{\text{Density of liquid}}{\text{Density of water}} = \frac{713.5}{1000} \quad \{\because\ \text{Density of water} = 1000 \text{ kg/m}^3\}$

$= \mathbf{0.7135.\ Ans.}$

2. Calculate the density, specific weight and weight of one litre of petrol of specific gravity = 0.7 .'

Ans:

Solution. Given : Volume = 1 litre = $1 \times 1000 \text{ cm}^3 = \frac{1000}{10^6} \text{ m}^3 = 0.001 \text{ m}^3$

Sp. gravity $S = 0.7$

(*i*) *Density* (ρ)

Using equation (1.1*A*),

Density (ρ) $= S \times 1000 \text{ kg/m}^3 = 0.7 \times 1000 = \mathbf{700 \text{ kg/m}^3}$. **Ans.**

(*ii*) *Specific weight* (*w*)

Using equation (1.1), $w = \rho \times g = 700 \times 9.81 \text{ N/m}^3 = \mathbf{6867 \text{ N/m}^3}$. **Ans.**

(*iii*) *Weight* (*W*)

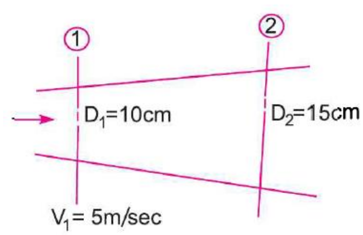
We know that specific weight $= \frac{\text{Weight}}{\text{Volume}}$

or $w = \frac{W}{0.001}$ or $6867 = \frac{W}{0.001}$

$\therefore$ $W = 6867 \times 0.001 = \mathbf{6.867 \text{ N}}$. **Ans.**

3. The Diameter of a pipe at section 1 and section 2 are 10 cm and 15 cm respectively. Find the discharge through the pipe if velocity of water flowing through the pipe at section 1 is 5 m/s. Determine also the velocity at section 2.

Ans:



At section 1, $D_1 = 10 \text{ cm} = 0.1 \text{ m}$

$$A_1 = \frac{\pi}{4}(D_1^2) = \frac{\pi}{4}(.1)^2 = 0.007854 \text{ m}^2$$

$V_1 = 5$ m/s.

At section 2, $D_2 = 15 \text{ cm} = 0.15 \text{ m}$

$$A_2 = \frac{\pi}{4}(.15)^2 = 0.01767 \text{ m}^2$$

(*i*) Discharge through pipe is given by equation (5.1)

or $Q = A_1 \times V_1$

$= 0.007854 \times 5 = \mathbf{0.03927 \text{ m}^3/\text{s}}$. **Ans.**

(*i*) Discharge through pipe is given by equation (5.1)

or $Q = A_1 \times V_1$

$= 0.007854 \times 5 = \mathbf{0.03927 \text{ m}^3/\text{s}}$. **Ans.**

(*ii*) $\therefore$ $V_2 = \frac{A_1 V_1}{A_2} = \frac{0.007854}{0.01767} \times 5.0 = \mathbf{2.22 \text{ m/s}}$. **Ans.**

<u>**Hydraulic Machines**</u>

Hydraulic machines are defined as those machines which convert either *hydraulic energy* into *mechanical energy* or ***mechanical* energy into *hydraulic energy.***

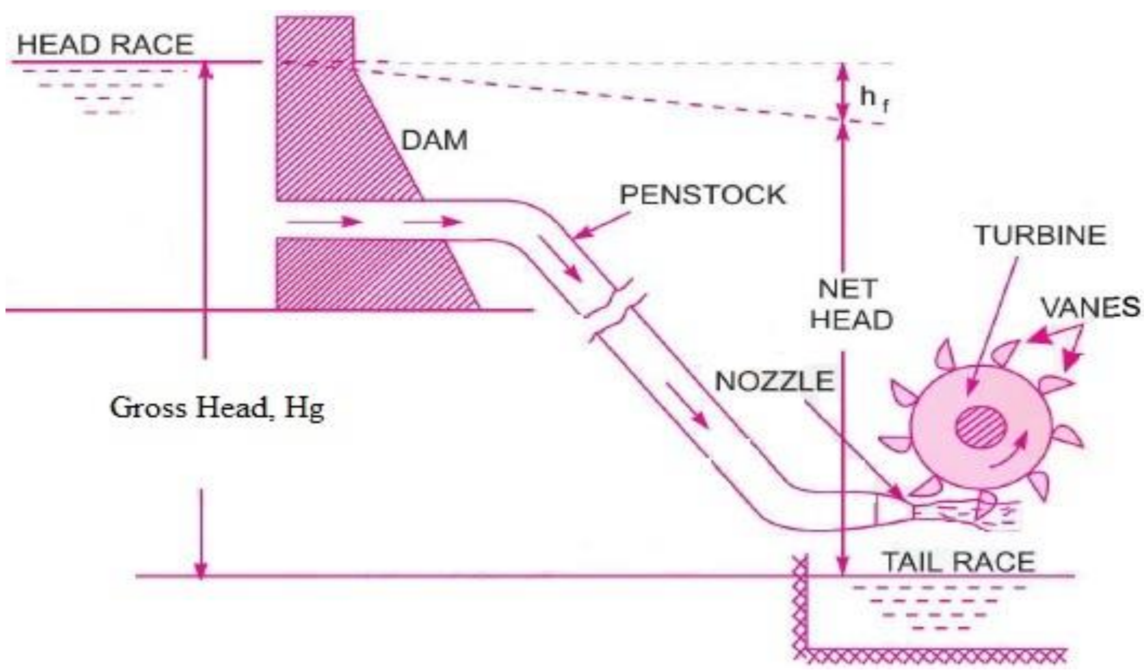
- ❖ Hydraulic Energy- Energy possessed by water.
- ❖ Mechanical Energy- power produced at shaft of turbine.
- ❖ Mechanical energy further converted into electrical energy.

The **hydraulic machines** which convert the hydraulic energy into mechanical energy are called as **turbine** and the **hydraulic machines** which converts mechanical energy into hydraulic energy, are called as **pump**.

Turbines are defined as the machines which convert the hydraulic energy into mechanical energy.

This mechanical energy is used in running an electric generator which is directly coupled to the shaft of the turbine. Thus, the mechanical energy is converted into electrical energy.

The electric power which is obtained from hydraulic energy is known as *Hydro-electric power*.



CLASSIFICATION OF HYDRAULIC TURBINES:

The Hydraulic turbines are classified according to the type of energy available at the inlet of the turbine, direction of flow through the vanes, head at the inlet of the turbine and specific speed of the turbine.

The following are the important classification of the turbines.

1. According to the type of energy at inlet:

a. Impulse turbine, b. Reaction turbine

2. According to the direction of flow through the runner:

a. Tangential flow turbine, b. Radial flow turbine,

c. Axial flow turbine, d. Mixed flow turbine.

3. According to the head at inlet of the turbine:

a. High head turbine,

b. Medium head turbine, and

c. Low head turbines.

4. According to the specific speed of the turbine:

a. Low specific speed turbine,

b. Medium specific speed turbine,

c. High specific speed turbine.

5. According to the position of shaft of the turbine:

a. Horizontal shaft turbine,

b. Vertical shaft turbine.

6. According to the name of originator:

a. Pelton turbine

b. Francis turbine

c. Kaplan turbine.

Impulse turbine:

- If at the inlet of turbine, the energy available is only kinetic energy, the turbine is known as Impulse turbine.

- As the water flows over the vanes, the pressure is atmospheric from inlet to outlet of the turbine.

Reaction turbine:

- If at the inlet of the turbine, the water possesses kinetic energy as well as pressure energy, the turbine is known as Reaction turbine.
- As the water flows through runner, the water is under pressure and the pressure energy goes on changing in to kinetic energy. The runner is completely enclosed in an air-tight casing and the runner and casing is completely full of water.

Tangential flow: If the water flows along the tangent of runner, the turbine is known as Tangential flow turbine.

Radial flow:

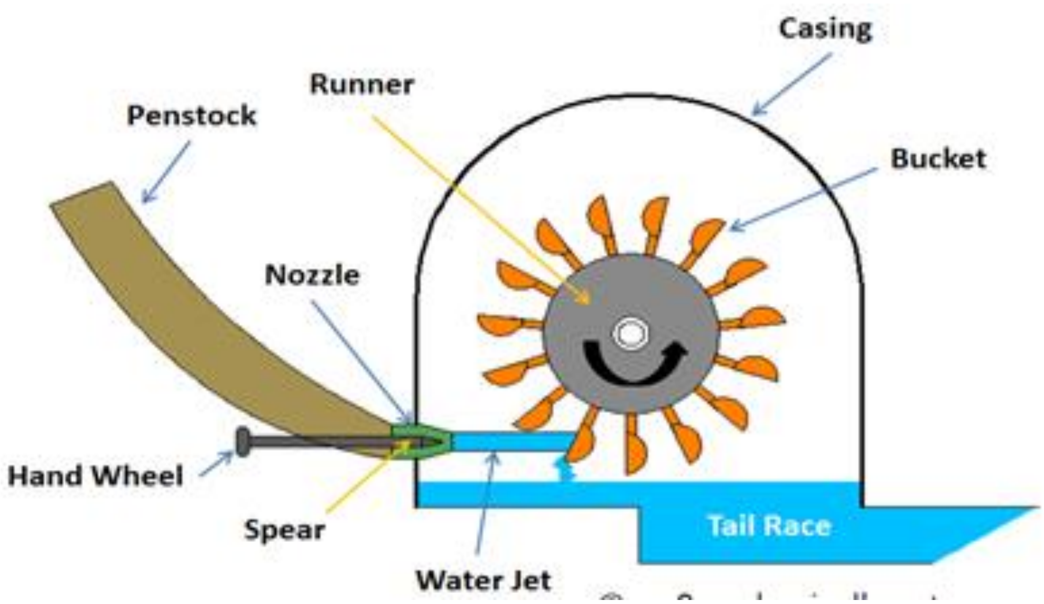
- If the water flows in the radial direction through the runner, the turbine is called Radial flow turbine.
- If the water flows from outward to inwards radially, the turbine is known as Inward radial flow turbine, on the other hand, if the water flows radially from inward to outwards, the turbine is known as outward radial flow turbine.

Axial flow: If the water flows through the runner along the direction parallel to the axis of rotation of the runner, the turbine is called axial flow turbine.

Mixed flow: If the water flows through the runner in the radial direction but leaves in the direction parallel to the axis of rotation of the runner, the turbine is called mixed flow turbine.

CONSTRUCTION AND WORKING OF IMPULSE TURBINES:

PELTON WHEEL (Turbine)



- It is a tangential flow impulse turbine. The water strikes the bucket along the tangent of the runner.
- The energy available at the inlet of the turbine is only kinetic energy. The pressure at the inlet and out let of turbine is atmospheric.
- This turbine is used for high heads and is named after L.A. Pelton an American engineer.
- The water from the reservoir flows through the penstocks at the out let of which a nozzle is fitted. The nozzle increases the kinetic energy of the water flowing through the penstock. At the outlet of the nozzle, the water comes out in the form of a jet and strikes the buckets (vanes) of the runner.

The main parts of the Pelton turbine are:

1. Nozzle and flow regulating arrangement (spear)

2. Runner and buckets,

3. Casing and Breaking jet.

Nozzle and flow regulating arrangement: The amount of water striking the buckets (vanes) of the runner is controlled by providing a spear in the nozzle. The spear is a conical needle which is operated either by hand wheel or automatically in an axial direction depending upon the size of the unit. When the spear is pushed forward in to the nozzle, the amount of water striking the runner is reduced. On the other hand, if the spear is pushed back, the amount of water striking the runner increases.

Runner with buckets: It consists of a circular disc on the periphery of which a number of buckets evenly spaced are fixed. The shape of the buckets is of a double hemispherical cup or bowl. Each bucket is divided in to two symmetrical parts by a dividing wall, which is known as splitter. The jet of water strikes on the splitter. The splitter divides the jet in to two equal parts and the jet comes out at the outer edge of the bucket.

The buckets are shaped in such a way that the jet gets deflected through an angle of 160° or 170°. The buckets are made of cast Iron, cast steel, Bronze or stainless steel depending upon the head at the inlet of the turbine.

Casing: The function of casing is to prevent the splashing of the water and to discharge the water to tailrace. It also acts as safeguard against accidents. It is made of Cast Iron or fabricated steel plates. The casing of the Pelton wheel does not perform any hydraulic function.

Breaking jet: When the nozzle is completely closed by moving the spear in the forward direction, the amount of water striking the runner reduces to zero. But the runner due to inertia goes on revolving for a long time. To stop the runner in a short time, a small nozzle is provided, which directs the jet of water on the back of the vanes. This jet of water is called Breaking jet.

CONSTRUCTION AND WORKING OF REACTION TURBINES:

RADIAL FLOW REACTION TURBINE:

In the Radial flow turbines water flows in the radial direction. The water may flow radially from outwards to inwards (i.e. towards the axis of rotation) or from inwards to outwards. If the water flows from outwards to inwards through the runner, the turbine is known as inwards radial flow turbine. And if the water flows from inwards to outwards, the turbine is known as outward radial flow turbine.

Reaction turbine means that the water at the inlet of the turbine possesses kinetic energy as well as pressure energy. As the water flows through the runner, a part of pressure energy goes on changing into kinetic energy. Thus, the water through the runner is under pressure. The runner is completely enclosed in an air-tight casing and the runner is always full of water.

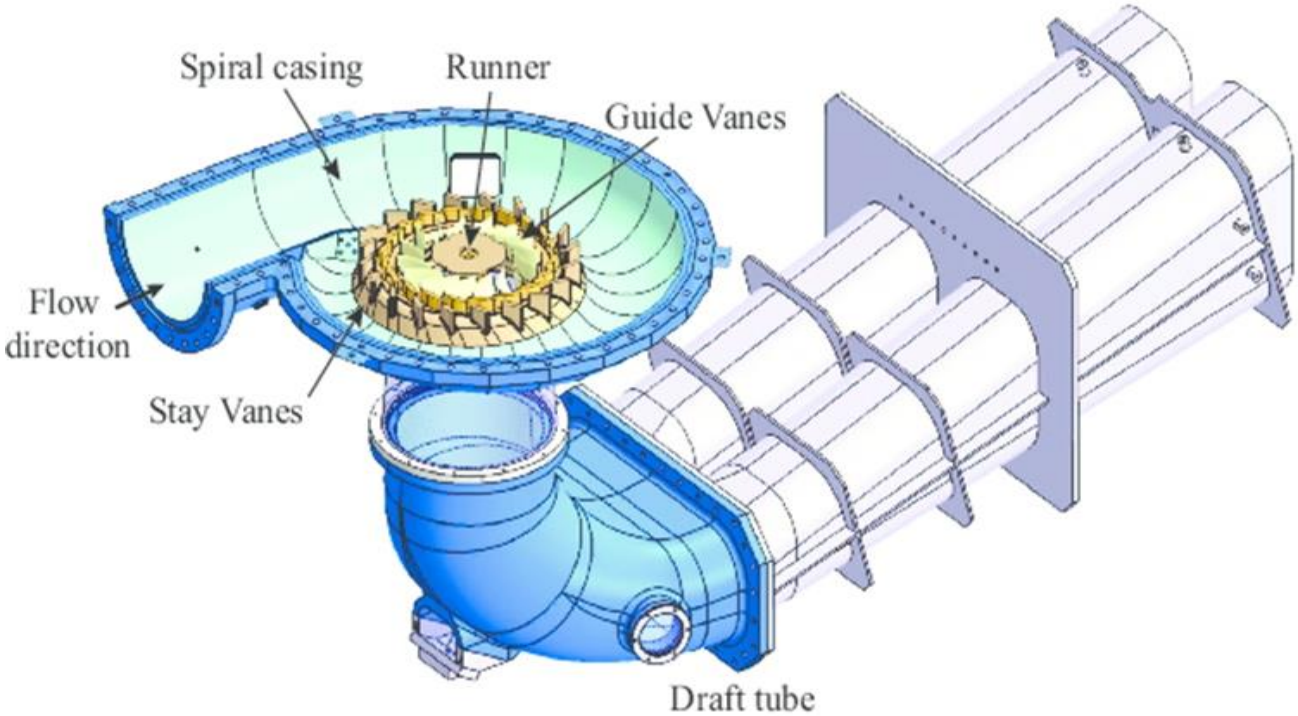
Main parts of a Radial flow Reaction turbine:

1. Casing,

2. Guide mechanism,

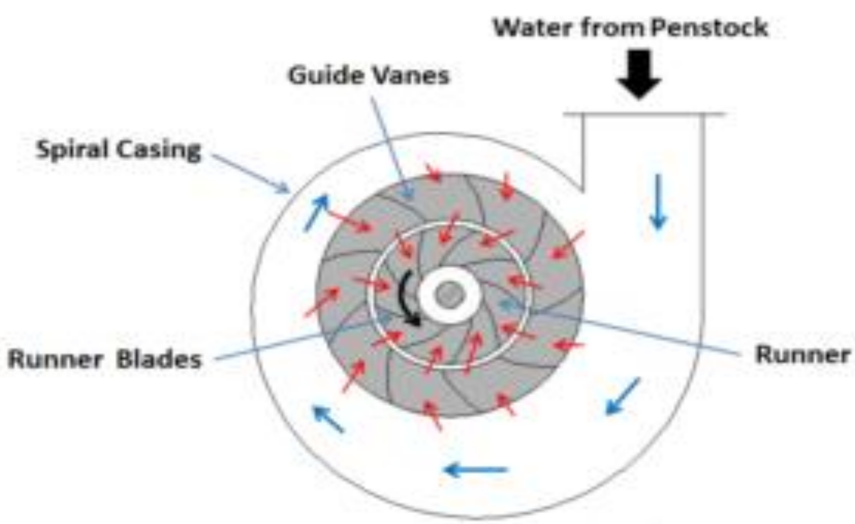
3. Runner and

4. Draft tube.



Casing: in case of reaction turbine, casing and runner are always full of water. The water from the penstocks enters the casing which is of spiral shape in which area of cross-section of the casing goes on decreasing gradually.

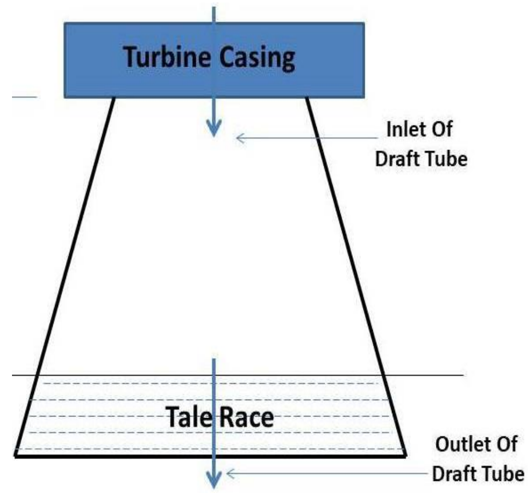
The casing completely surrounds the runner of the turbine. The water enters the runner at constant velocity throughout the circumference of the runner.



Guide Mechanism: It consists of a stationary circular wheel all around the runner of the turbine. The stationary guide vanes are fixed on the guide mechanism. The guide vanes allow the water to strike the vanes fixed on the runner without shock at inlet. Also, by suitable arrangement, the width between two adjacent vanes of guide mechanism can be altered so that the amount of water striking the runner can be varied.

Runner: It is a circular wheel on which a series of radial curved vanes are fixed. The surfaces of the vanes are made very smooth. The radial curved vanes are so shaped that the water enters and leaves the runner without shock. The runners are made of cast steel, cast iron or stain less steel. They are keyed to the shaft.

Draft Tube: The pressure at the exit of the runner of a reaction turbine is generally less than atmospheric pressure. The water at exit can't be directly discharged to the tail race. A tube or pipe of gradually increasing area is used for discharging the water from the exit of the turbine to the tail race. This tube of increasing area is called draft-tube.



PUMP

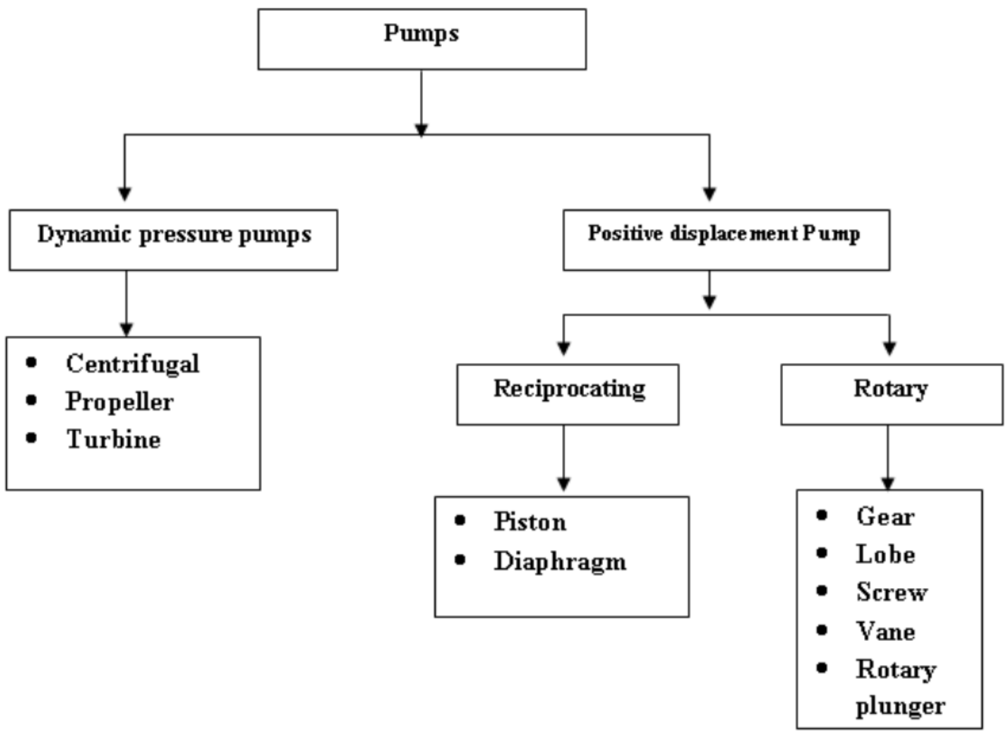
The hydraulic machines which convert the mechanical energy in to hydraulic energy are called pumps.

The hydraulic energy is in the form of **pressure energy**. If the mechanical energy is converted in to pressure energy by means of centrifugal force acting on the fluid, the hydraulic machine is called **centrifugal pump**.

Classification of pump:

There exist a wide variety of pumps that are designed for various specific applications. However, most of them can be broadly classified into two categories as mentioned below-

1. Dynamic Pressure Pumps
2. Positive Displacement Pump



Construction and Working of Pump:

The centrifugal pump acts as a reversed of an inward radial flow reaction turbine. This means that the flow in centrifugal pumps is in the radial outward directions.

The centrifugal pump works on the principle of forced vertex flow which means that when a certain mass of liquid is rotated by an external torque, the rise in pressure head of the rotating liquid takes place.

The rise in pressure head at any point of the rotating liquid is proportional to the square of tangential velocity of the liquid at that point. (i.e. rise in pressure head = $v^2/2g$ or $\omega^2 r^2/2g$). Thus, the outlet of the impeller, where radius is more, the rise in pressure head will be more and the liquid will be discharged at the outlet with a high-pressure head. Due to this high-pressure head, the liquid can be lifted to a high level.

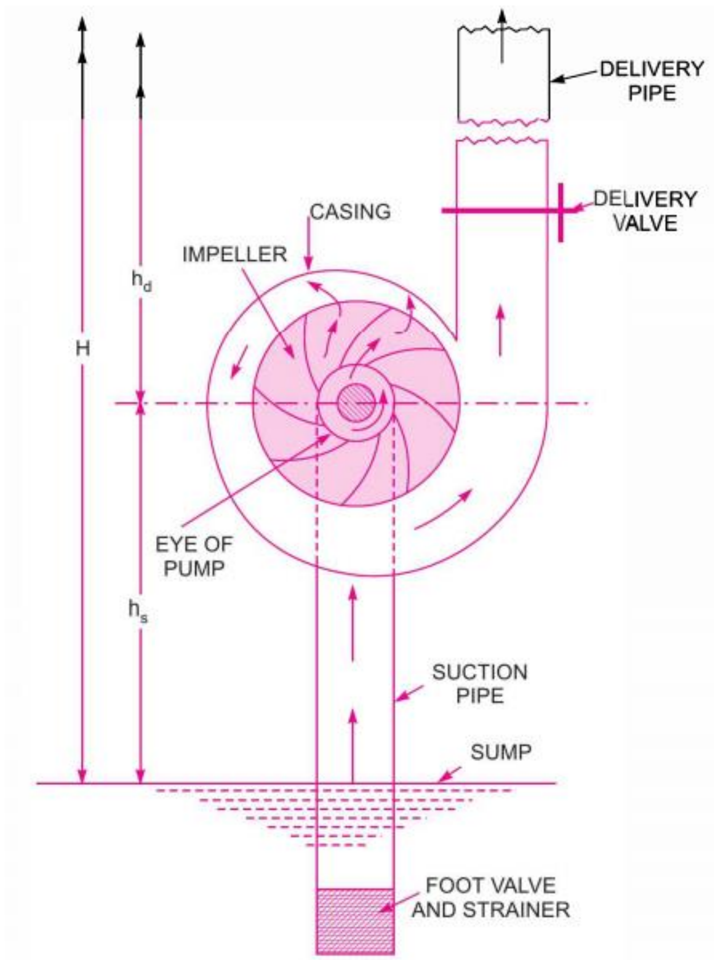
<u>The following are the main parts of a centrifugal pump:</u>

1) Impeller.

2) Casing.

3) Suction pipe with foot valve and a strainer

4) Delivery pipe.



Impeller: The rotating part of a centrifugal pump is called impeller. It consists of a series of backward curved vanes. The impeller is mounted on a shaft which is connected to the shaft of an electric motor.

Casing: the casing of a centrifugal pump is similar to the casing of a reaction turbine. It is an air tight passage surrounding the impeller and is designed in such a way that the kinetic energy of the water discharged at the outlet of the impeller is converted in to pressure energy before the water leaves the casing and enters the delivery pipe.

The following three types of the casing are commonly adopted.

(a) Volute, (b) Vortex, (c) Casing with guide blades

Volute Casing: It is the casing surrounding the impeller. It is of a spiral type, in which area of flow increases gradually. The increase in area of flow decreases the velocity of flow. The decrease in velocity increases the pressure of the water flowing through the casing. It has been observed that in case of volute casing, the efficiency of the pump decreases slightly as a large amount of energy is lost due to the formation of eddies in this type of casing.

Vortex Casing: If a circular chamber is introduced between the casing and the impeller, the casing is known as vortex casing. By introducing the circular chamber, the loss of energy due to the formation of eddies is reduced to a considerable extent. Thus the efficiency of the pump is more than the efficiency when only volute casing is provided.

Casing with guide blades: in this type of casing the impeller is surrounded by a series of guide blades mounted on a ring known as diffuser. The guide vanes are designed in which away that the water from the impeller enters the guide vanes without shock. Also, the area of guide vanes increases thus reducing the velocity of flow through guide vanes and consequently increasing the pressure of the water. The water from the guide vanes then passes through the surrounding casing, which is in most of the cases concentric with the impeller.

Suction pipe with a foot valve and a strainer: A pipe whose one end is connected to the inlet of the pump and other end dips in to water in a sump is known as suction pipe.

A **foot valve** which is a non-return valve or one-way type of valve is fitted at the lower end of the suction pipe. The foot valve opens only in the upward direction.

A **strainer** is also fitted at the lower end of the suction pipe.

Delivery pipe: A pipe whose one end is connected to the outlet of the pump and the other end delivers the water at the required height is known as delivery pipe.

HEADS OF A CENTRIFUGAL PUMP:

Suction Head: It is the vertical height of the centre line of centrifugal pump, above the water surface in the tank or sump from which water is to be lifted. This height is also called suction lift ′h_s′.

Delivery Head: The vertical distance between the centre line of the pump and the water surface in the tank to which water is delivered is known as delivery head. This is denoted by ′h_d′.

Static Head: The sum of suction head and delivery head is known as statics head. This is denoted by ′H′.

$H = h_s + h_d$

Manometric Head: Manometric head is defined as the head against which a centrifugal pump has to work. It is denoted by Hm

RECIPROCATING PUMPS:

The mechanical energy is converted in to hydraulic energy (pressure energy) by sucking the liquid in to a cylinder in which a piston is reciprocating, which exerts the thrust on the liquid and increases its hydraulic energy (pressure energy) the pump is known as reciprocating pump.

Classification of Reciprocating Pump

1. According to the water being in contact with one side or both sides of the piston-
   A. Single acting pump
   B. Double acting pump
2. According to the number of cylinders provided

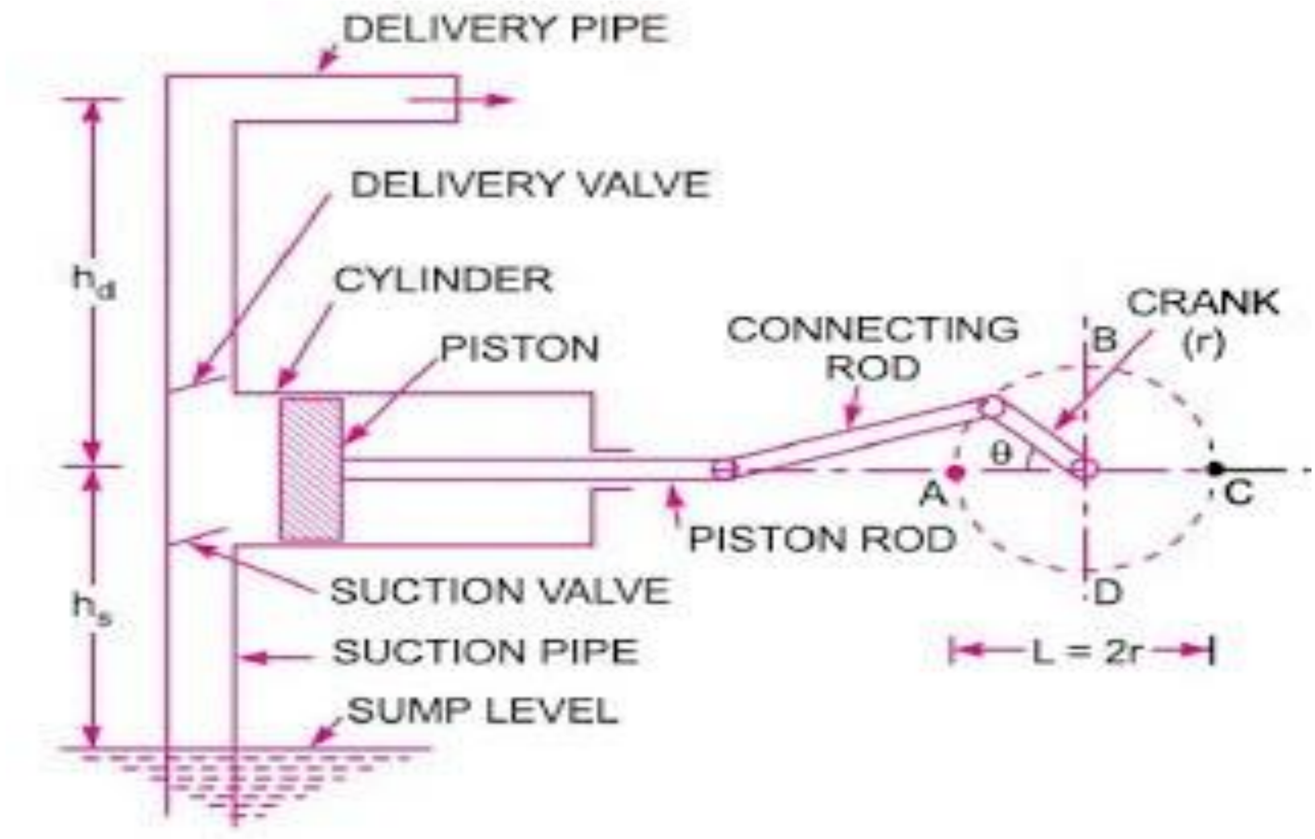
A. Single cylinder pump,

B. Double cylinder pump,

C. Triple cylinder pump.

<u>The main components of R.P.:</u>

1. Cylinder.
2. Piston and Piston Rod.
3. Crank and Connecting Rod.
4. Suction Pipe.
5. Suction Valve.
6. Delivery Pipe.
7. Delivery Valve.



Working of Reciprocating Pump:

When the power source is connected to crank, the crank will start rotating and connecting rod also displaced along with crank.

The piston connected to the connecting rod will move in linear direction. If crank moves outwards then the piston moves towards its right and create vacuum in the cylinder.

This vacuum causes suction valve to open and liquid from the source is forcibly sucked by the suction pipe into the cylinder.

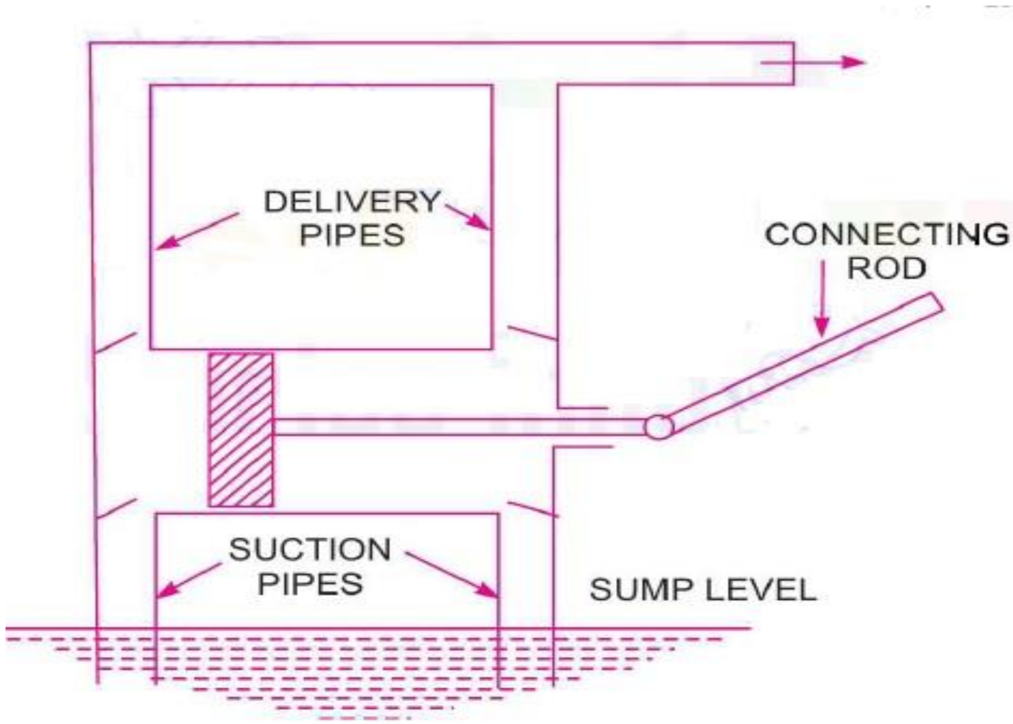
When the crank moves inwards or towards the cylinder, the piston will move towards its left and compresses the liquid in the cylinder.

Now, the pressure makes the delivery valve to open and liquid will discharge through delivery pipe.

When piston reaches its extreme left position whole liquid present in the cylinder is delivered through delivery valve.

Then again, the crank rotates outwards and piston moves right to create suction and the whole process is repeated.

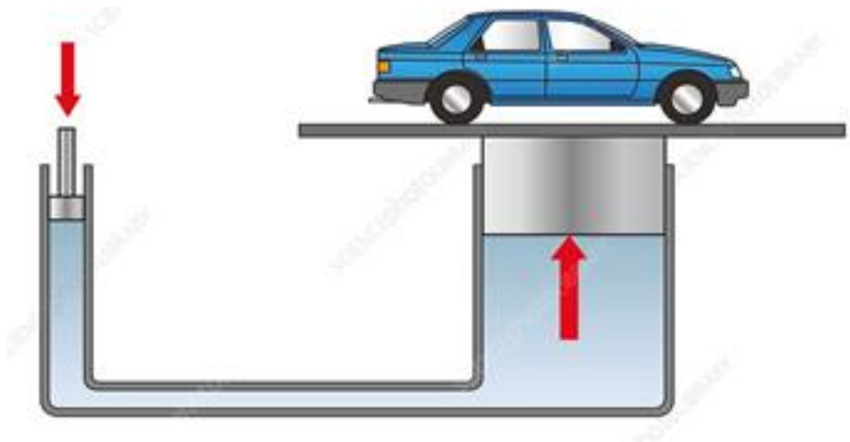
Generally, the above process can be observed in a single acting reciprocating pump where there is only one delivery stroke per one revolution of crank. But when it comes to ***double acting reciprocating pump***, there will be two delivery strokes per one revolution of crank



Hydraulic lift

Hydraulic lift is a device used for carrying passenger or goods from one floor to another in multistoried building to raise heavy objects.

It works on the principle of Pascal's Law.



The Hydraulic Lifts are of two types-

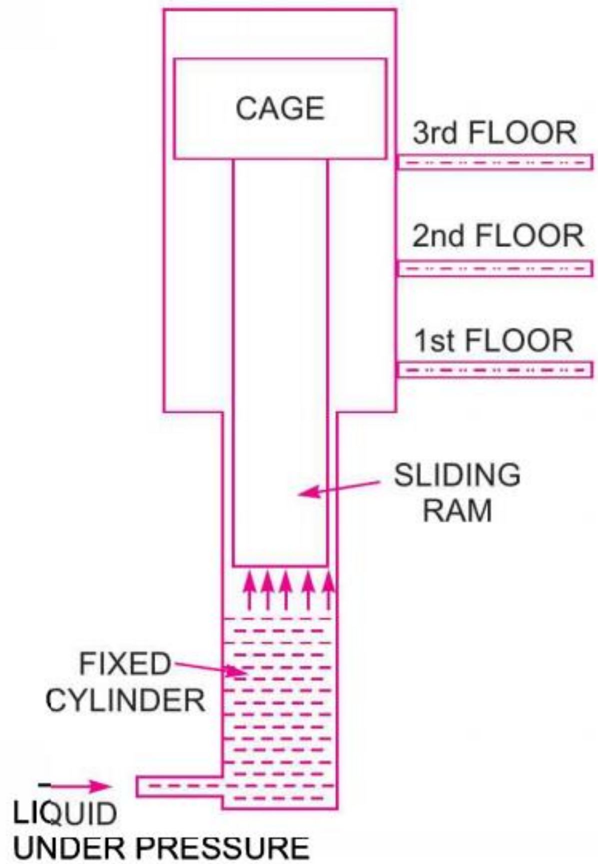
1. Direct acting hydraulic lift
2. Suspended hydraulic lift

Direct acting hydraulic lift:

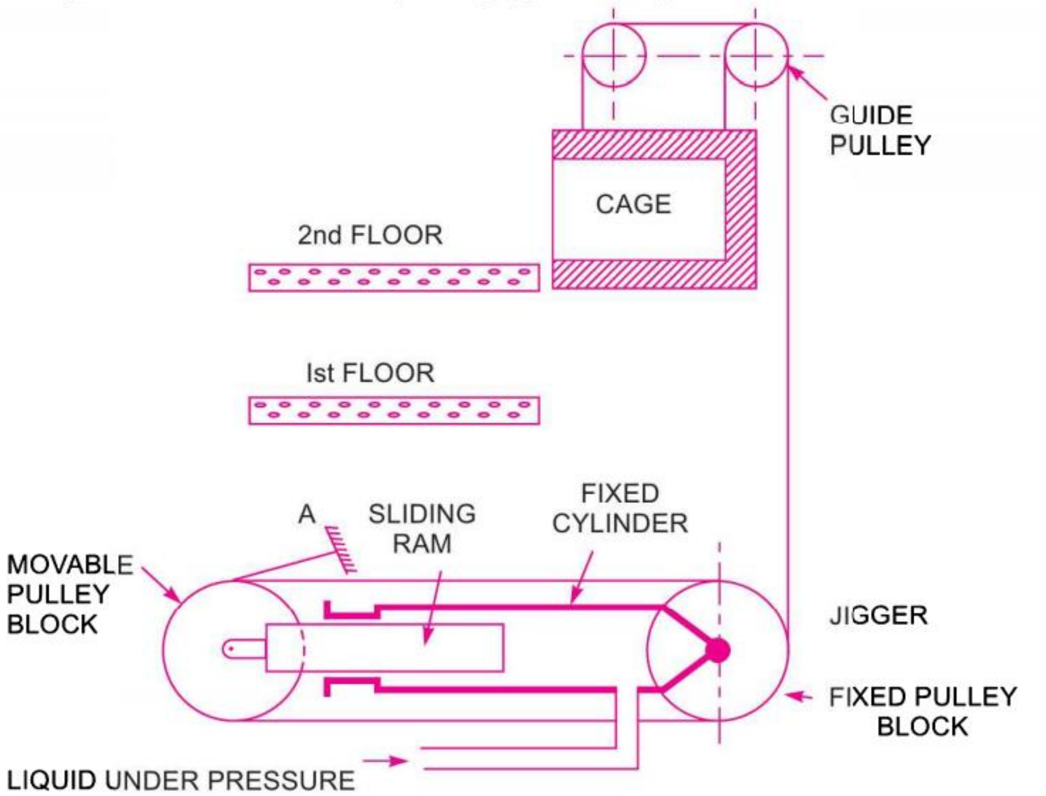
It consists of a ram, sliding in the fixed cylinder. At the top of the sliding ram a cage is fitted.

Cage- on which the person may be stand or goods may be placed.

The liquid under pressure flows into fixed cylinder. This liquid exerts force on the sliding ram, which moves vertically up and thus raises the cage to the required height.


CAGE
3rd FLOOR
2nd FLOOR
1st FLOOR
SLIDING
RAM
FIXED
CYLINDER
LIQUID
UNDER PRESSURE

Suspended hydraulic lift



When water under high pressure is admitted into the fixed cylinder of the jigger, the sliding ram is forced to move towards left.

As one of the ends of the sliding ram is connected to the movable pulley block. Hence the movable pulley block moves towards the left, thus increasing the distance between two pulley blocks.

The wire rope connected to cage is pulled and the cage is lifted.

For lowering the cage, water from fixed cylinder is taken out.

The sliding ram moves towards right and hence movable pulley block also moves towards right.

This decrease the distance between two pulley blocks and cage is lowered due to increased length of the rope

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