AKTU

B. Tech I-Year

Gateway Classes

GATEWAY CLASSES

Semester -I & II

Common to All Branches

Fundamentals of Mech. Engg.(BME101/201)

Unit-4 : ONE SHOT-Fluid Mechanics & Applications

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- Long - Short Questions Covered
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- Result Oriented Content

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Fundamentals of Mech. Engg.(BME101/201)

Unit-4

Introduction to Fluid Mechanics & Applications

Syallbus

Introduction: Fluids properties, pressure, density, dynamic and kinematic viscosity, specific gravity, Newtonian and Non-Newtonian fluid, Pascal's Law and Continuity Equation.

Working principles of hydraulic turbines (Pelton Wheel and Francis)& pumps (Centrifugal and Reciprocating) and their classifications and hydraulic lift.

AKTU B.TECH I-YEAR FME

FUND. OF MECHANICAL ENGG.

FINAL REVISION + NOTES

UNIT-4 FLUID MECHANICS AND APPLICATIONS

QUESTIONS तो यहीं से आएंगे !

LIVE 19 MARCH 2 PM

BY M S TOMER SIR

AKTU B.TECH I-YEAR FME

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FINAL REVISION + NOTES

UNIT-5 MECHATRONICS

QUESTIONS तो यहीं से आएंगे !

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BY M S TOMER SIR

FUNDAMENTALS OF MECHANICAL ENGINEERING (FME)

UNIT- 4 : Introduction to Fluid Mechanics and Applications

AKTU : Syllabus

Introduction:

- Fluids properties, pressure, density, dynamic and kinematic viscosity, specific gravity
- Newtonian and Non-Newtonian fluid
- Pascal's Law and Continuity Equation

- Working principles of hydraulic turbines (Pelton Wheel and Francis)& pumps (Centrifugal and Reciprocating) and their classifications and hydraulic lift.

Introduction

❖ A matter exists in either the solid state or the fluid state.

❖ The fluid state is further divided into

➢ Liquid state

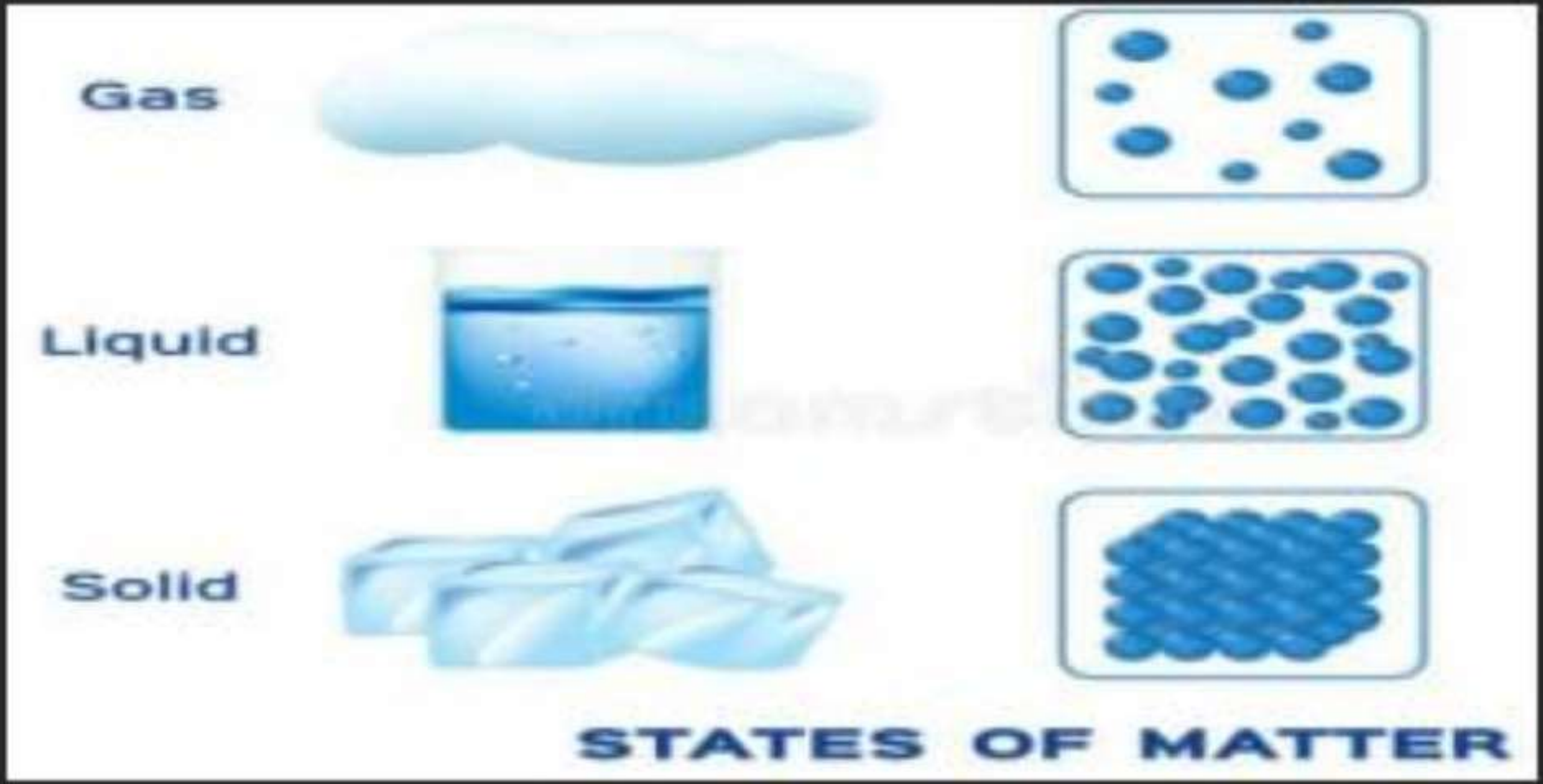
➢ Gaseous state

❖ In fact the same matter may exist in any one of the three states i.e. solid, liquid and gaseous.

❖ For example water occurs in a liquid state, may also occur in solid state as ice and in a gaseous state as vapour.

....Introduction

- In solids the molecules are very closely spaced.
- In liquids the spacing between the molecules is relatively large.
- In gases the space between the molecules is still larger.



Fluid

- Fluid may be defined as a substance which is capable of flowing.
- It has no definite shape of its own, but conforms to the shape of the containing vessel.

OR

- “A fluid is a substance which deforms continuously under the action of tangential or shear force.”

- Examples of fluids are : Water, Milk, Kerosene, Petrol, Gases etc

Fluid Mechanics

- "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 and biomedical engineering etc.

Basic Properties of Fluid

1. Pressure
2. Density
3. Specific Weight
4. Specific Gravity
5. Dynamic Viscosity
6. Kinematic Viscosity

1. Pressure

❖ "It is defined as normal force per unit area."

$$\boxed{P = \frac{F}{A}}$$

❖ It is a scalar quantity.

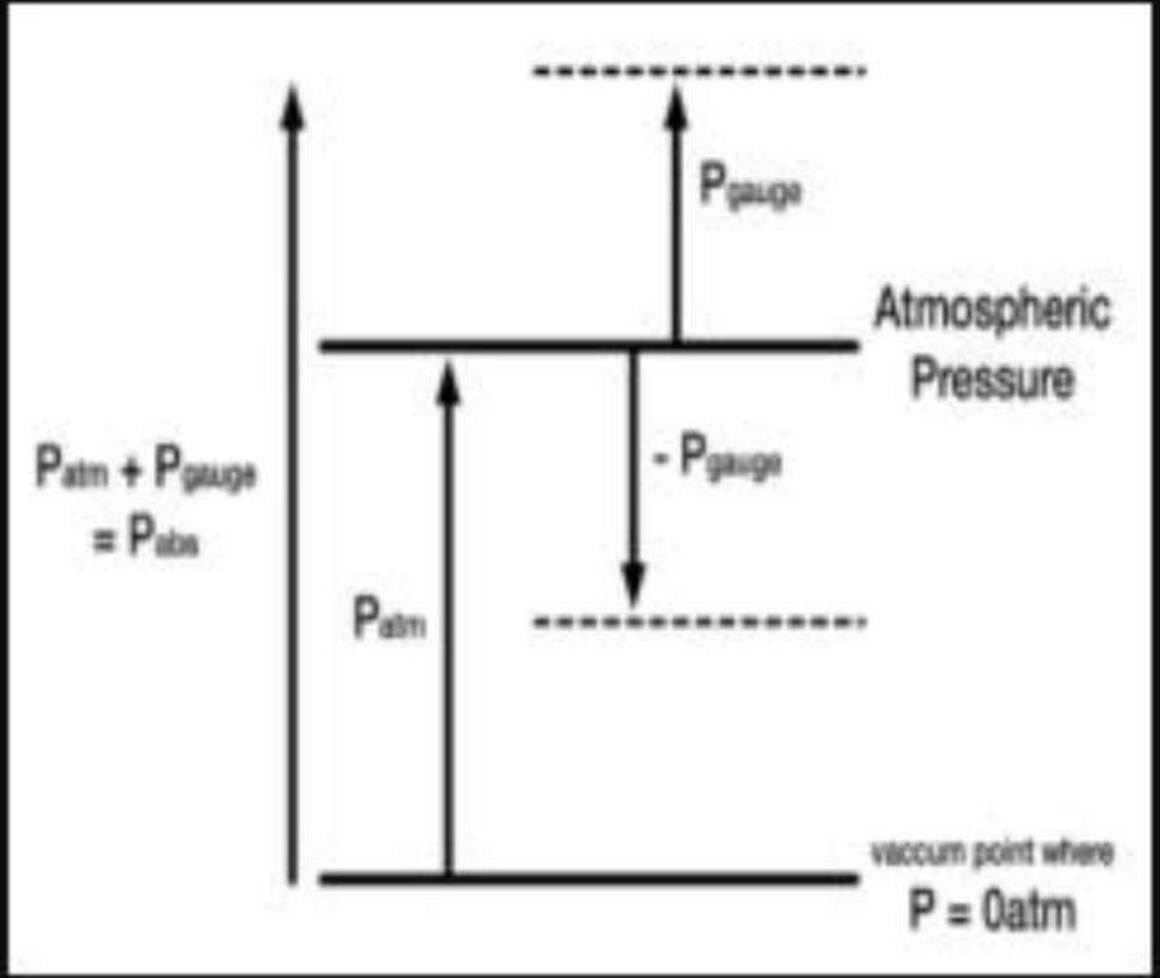
❖ Units of Pressure :

➢ N/m^2

➢ Pascal (Pa) (1 Pa = 1 N/m^2)

➢ atm (1 atm = 101325 Pa = 101.325 kPa)

➢ Bar (1 bar $=10^5$ Pa = 10^5 N/m^2



Numerical 4.1

AKTU : 2021-22

What is the absolute pressure experienced by a pressure sensor, if the atmospheric pressure of a fluid is 2 atm, gauge pressure is 5 atm and differential pressure is 3 atm.

Soln.

given, $P_{atm} = 2\ atm$

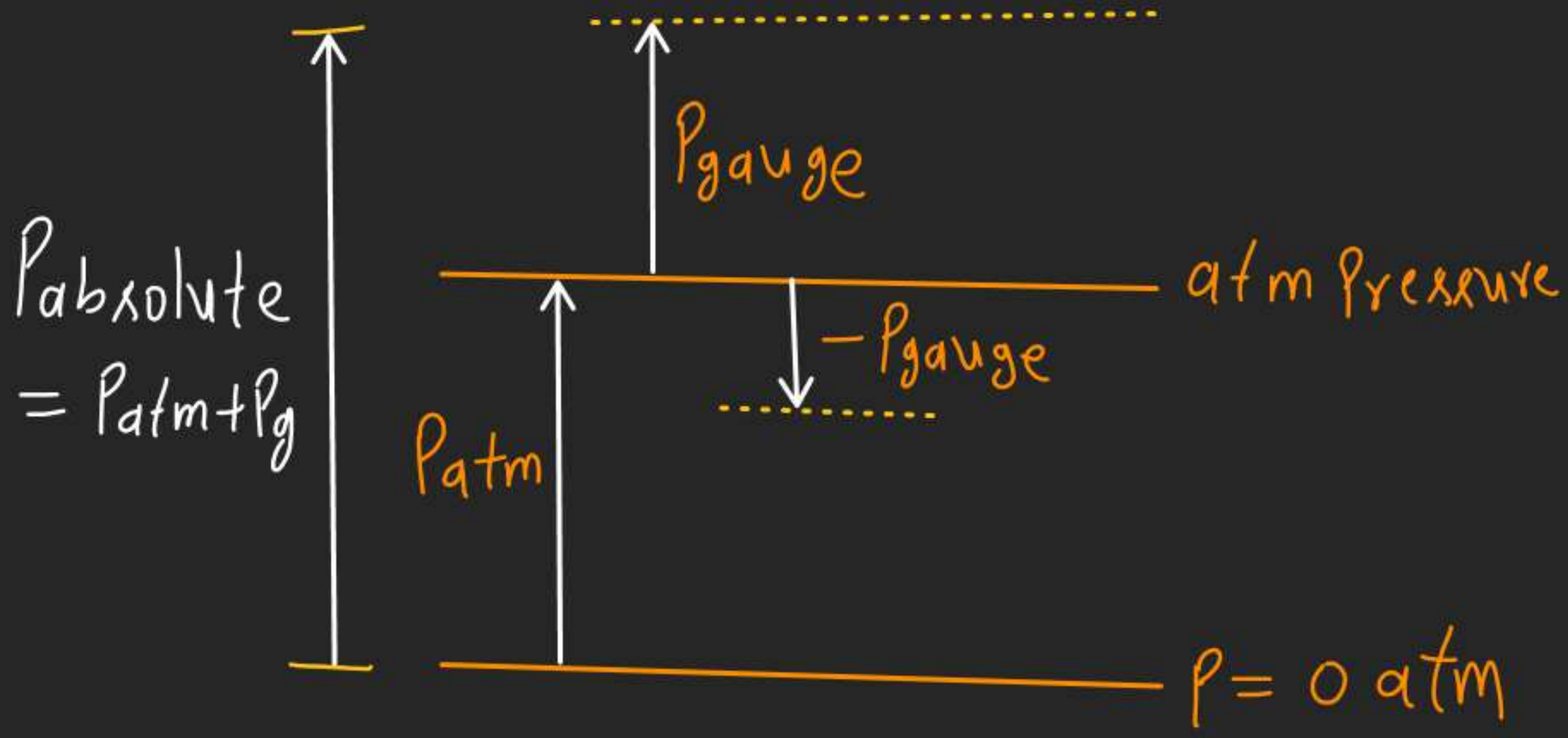
$P_{gauge} = 5\ atm$

$P_{absolute} = ?$

$$P_{absolute} = P_{atm} + P_{gauge}$$

$$= 2 + 5$$

$$\boxed{P_{absolute} = 7\ atm}$$ Ans



2. Density(ρ) or Mass Density

- "It is defined as mass per unit volume of the substance."

$$\boxed{\rho = \frac{m}{V}}$$

- **Units of density**
  - Kg/m^3
  - g/cm^3 or g/cc($1\ g/cc = 10^3\ kg/m^3$)

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

3.Specific Weight (ω)

- Specific weight is also known as weight density.

- "It is defined as weight per unit volume of substance."

$$\boxed{\omega = \frac{weight}{Volume} = \frac{mg}{V} = \rho g} \qquad [\rho = \frac{m}{V}]$$

- Unit of specific weight is N/m^3

4. Specific Gravity(s)

- “ It is defined as the density of the fluid w.r.t. the density of standard fluid.”

- $$\text{Specific Gravity(s)} = \frac{density\ of\ fluid}{density\ of\ standard\ fluid}$$

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

- For gases, standard fluid is Air.

Numerical-4.2

AKTU : 2022-23

GW GATEWAY CLASSES

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

liquid ← fluid → std. fluid → water → $\rho_w = 1000\,kg/m^3$

Sol^n: given.

Volume (V) = 1 litre $= 1\times10^{-3}\,m^3$

Weight (W) = 7 N

To determine:

(a) sp wt = ?

(b) density (ρ) = ?

(c) sp. gravity = ?

(a) $sp.\ wt = \dfrac{\text{Weight}}{\text{Volume}} = \dfrac{7\,N}{1\times10^{-3}\,m^3}$

$\boxed{sp.\ wt. = 7000\ N/m^3}$ Ans

(b) $sp.\ wt = \rho . g \Rightarrow 7000 = \rho \times 9.81$

$\Rightarrow \boxed{\rho = 713.55\ kg/m^3}$ Ans

(c) $sp.\ gravity = \dfrac{\rho_{fluid}}{\rho_{std\ fluid}} \Rightarrow sp.\ gr. = \dfrac{713.55}{1000}$

$\Rightarrow \boxed{sp.\ gr. = 0.713}$ Ans

Numerical-4.3

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

Try your self

Ans:

$\rho = 700 \ kg/m^3$

$sp.wt = 6867 \ N/m^3$

5. Dynamic 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."

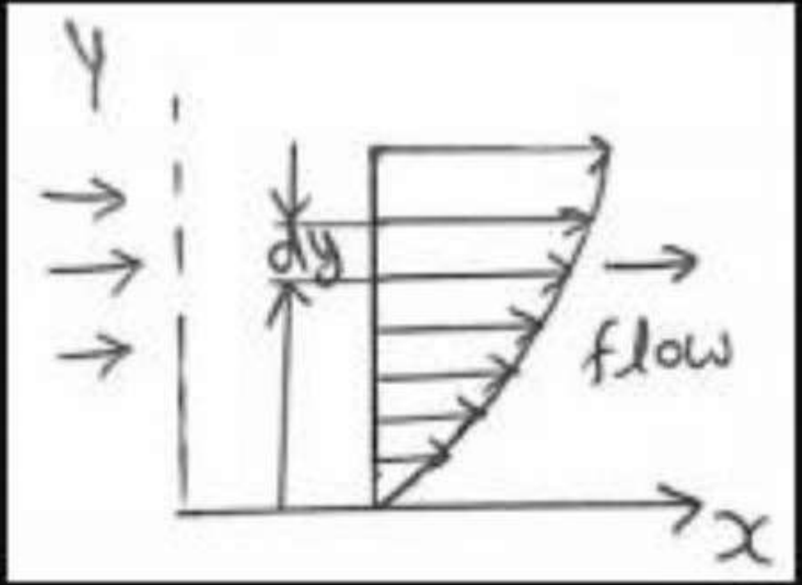
❖Therefore the frictional force between the adjacent layers is known as viscous shear force.

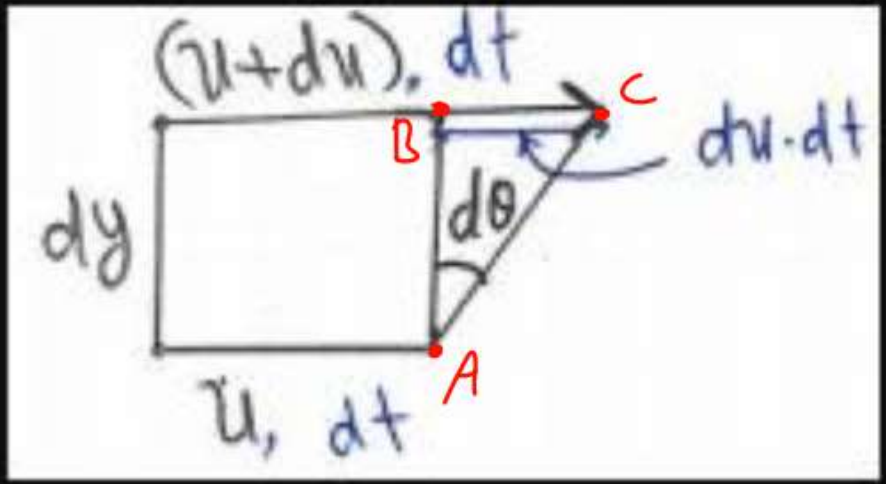
In $\triangle ABC$

$\tan d\theta = \frac{du\,dt}{dy}$

$\because d\theta$ is very very small, $\tan d\theta \simeq d\theta$

$d\theta = \frac{du\,dt}{dy} \Rightarrow \boxed{\frac{d\theta}{dt} = \frac{du}{dy}}$





Where $\frac{d\theta}{dt}$ = Rate of angular(shear) deformation and

$\frac{du}{dy}$= Velocity gradient.

Cause of Viscosity

- Basic cause of viscosity is cohesive forces between the molecules.

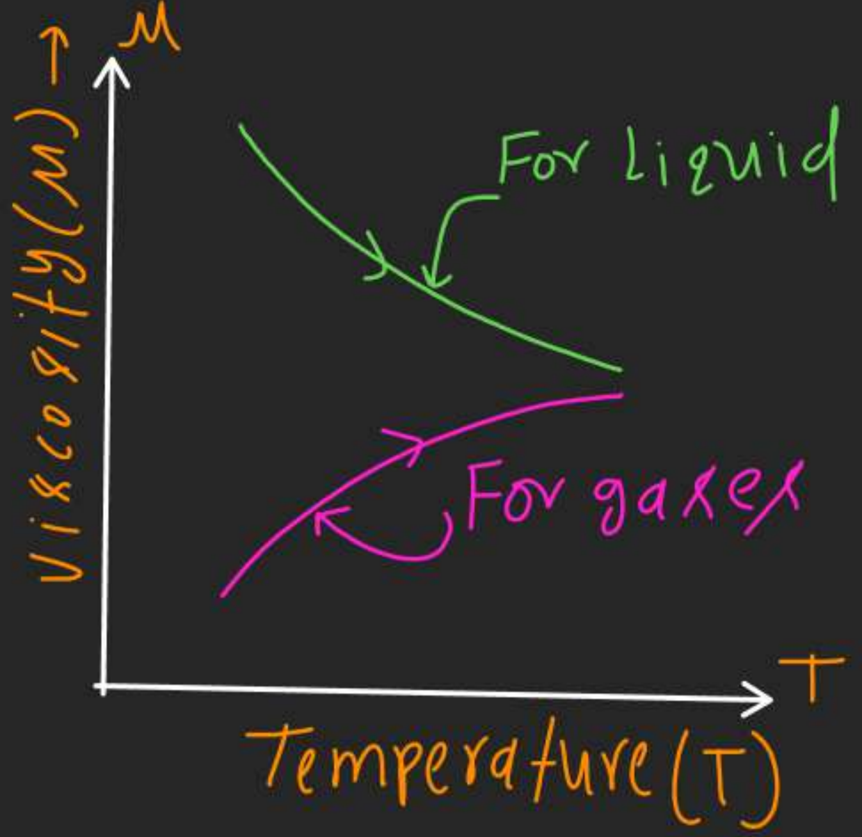
- Because in case of liquid cohesive force is high and in case of gases cohesive force is very less.

- Therefore viscosity of liquid is very high as compared to viscosity of gases.

Dependency of Viscosity on Temperature

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

- Viscosity of gases increases with increase in temperature.[if T↑ then randomness↑]



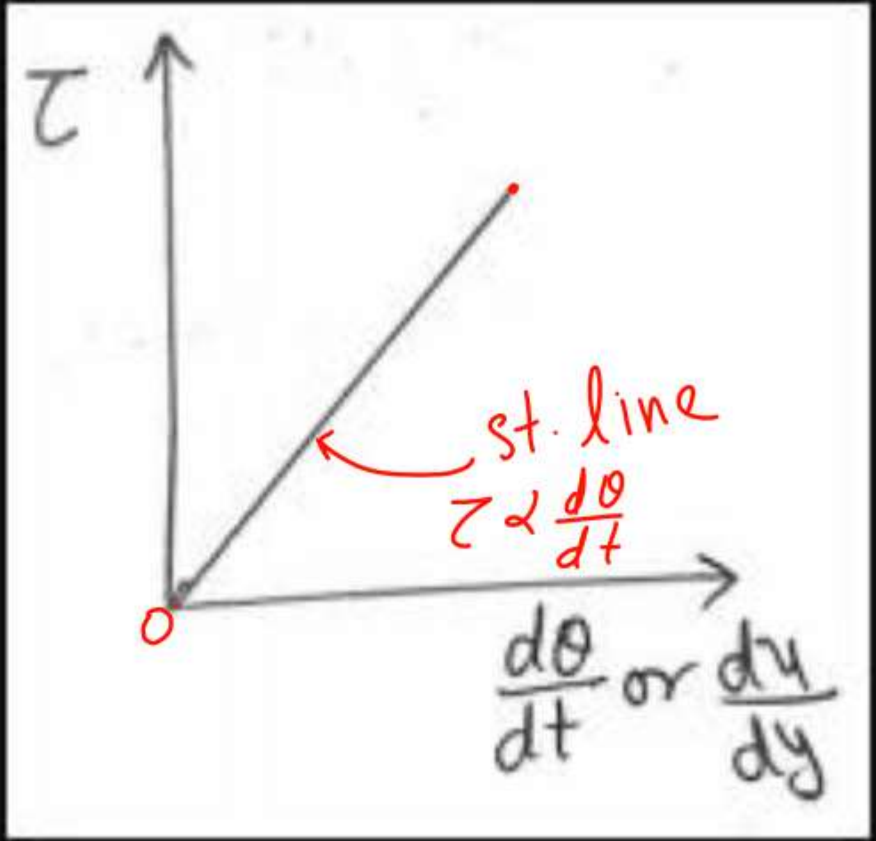
Newton's law of Viscosity

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

Mathematically,

$$\tau \propto \frac{d\theta}{dt} \Rightarrow \tau \propto \frac{du}{dy} \quad \left[\because \frac{d\theta}{dt} = \frac{du}{dy}\right]$$

$$\boxed{\tau = \mu \frac{du}{dy}}$$



- Where μ is proportionality constant(property of fluid) which is known as viscosity or dynamic viscosity.

$\tau = \mu \frac{du}{dy}$

$\mu = \tau / \frac{du}{dy}$

$\frac{\tau}{\frac{du}{dy}} \rightarrow \frac{N/m^2}{\frac{\cancel{m}/s}{\cancel{m}}} \Rightarrow \frac{N \cdot s}{m^2}$

Force, F

$F = ma$

$= kg \times \frac{m}{s^2}$

$kg \times \frac{\cancel{m}}{s^{\cancel{2}}} \times \frac{\cancel{s}}{m^{\cancel{2}}}$

$\frac{kg}{m \cdot s}$

❖Unit of viscosity

➢MKS : $\boxed{\frac{N-s}{m^2}} = \frac{kg-m}{s^2} \text{X} \frac{s}{m^2} = \frac{kg}{m-s}$ [F = ma]

➢CGS : $\frac{gm}{cm-s} = \frac{10^{-3}kg}{10^{-2}\, m-s} = 0.1 \frac{kg}{m-s} = 0.1 \frac{N-s}{m^2}$

❖$\frac{gm}{cm-s}$ = 1 Poise = 0.1 $\frac{N-s}{m^2}$

6. Kinematic Viscosity

❖"Ratio of dynamic Viscosity and density is called Kinematic Viscosity.

$$\boxed{v = \frac{\mu}{\rho}} \rightarrow \frac{N \cdot s/m^2}{kg/m^3}$$

Force, F

$F = ma$

$= kg \cdot \frac{m}{s^2}$

$$\Rightarrow \frac{\cancel{kg} \cdot \frac{m}{s^2} s / m^2}{\cancel{kg} / m^3}$$

$\Rightarrow m^2/s$

Unit of Kinematic Viscosity

➢MKS : m^2/s

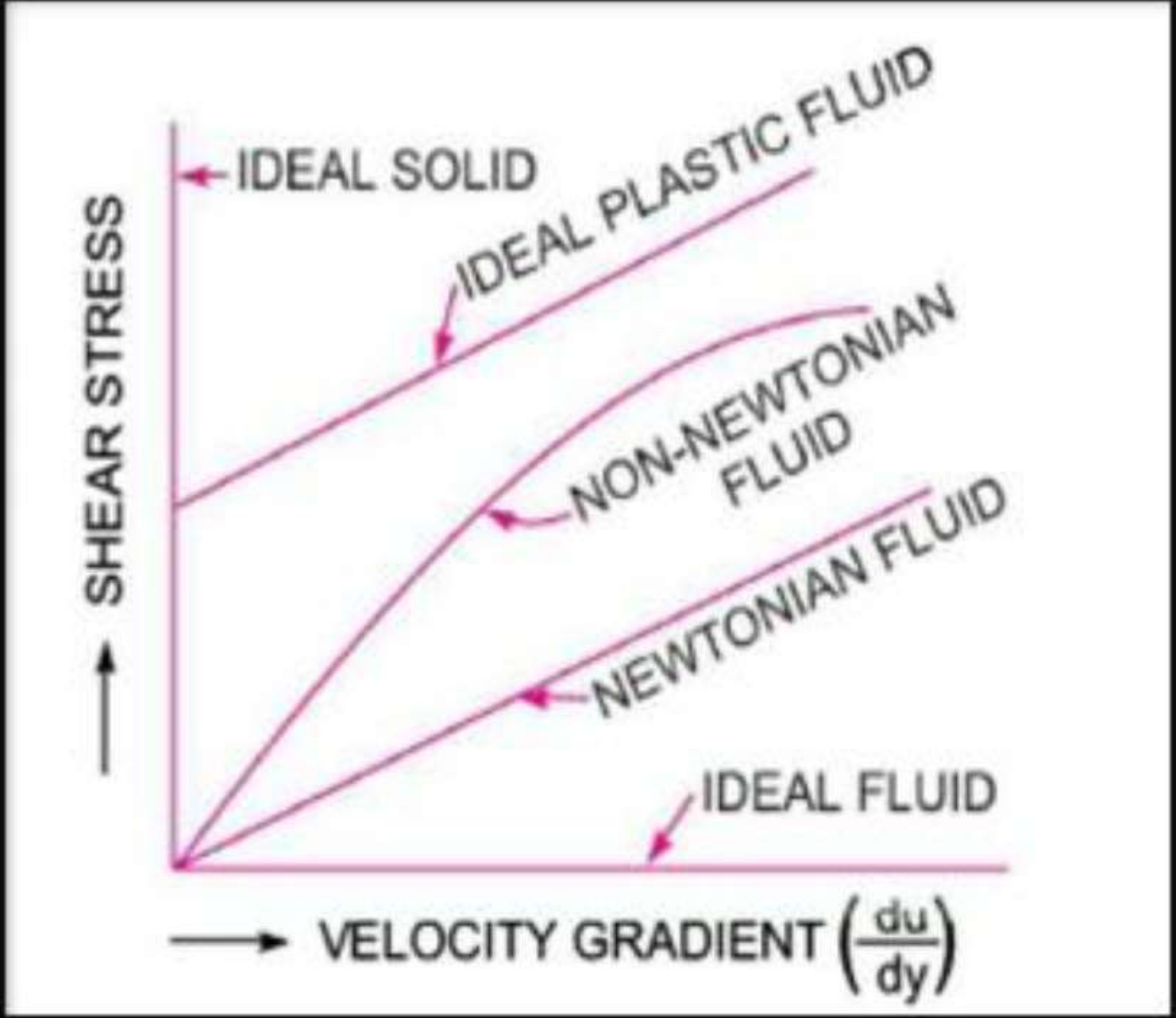
➢CGS : cm^2/s

$$1\,\frac{cm^2}{s} = 10^{-4}\,\frac{m^2}{s} = 1 \text{ stoke}$$

Types of Fluid

The fluid may be classified into the following five types:

1. Real fluid
2. Ideal fluid
3. Newtonian fluid
4. Non-Newtonian fluid
5. Ideal plastic fluid



$\mu \neq 0$

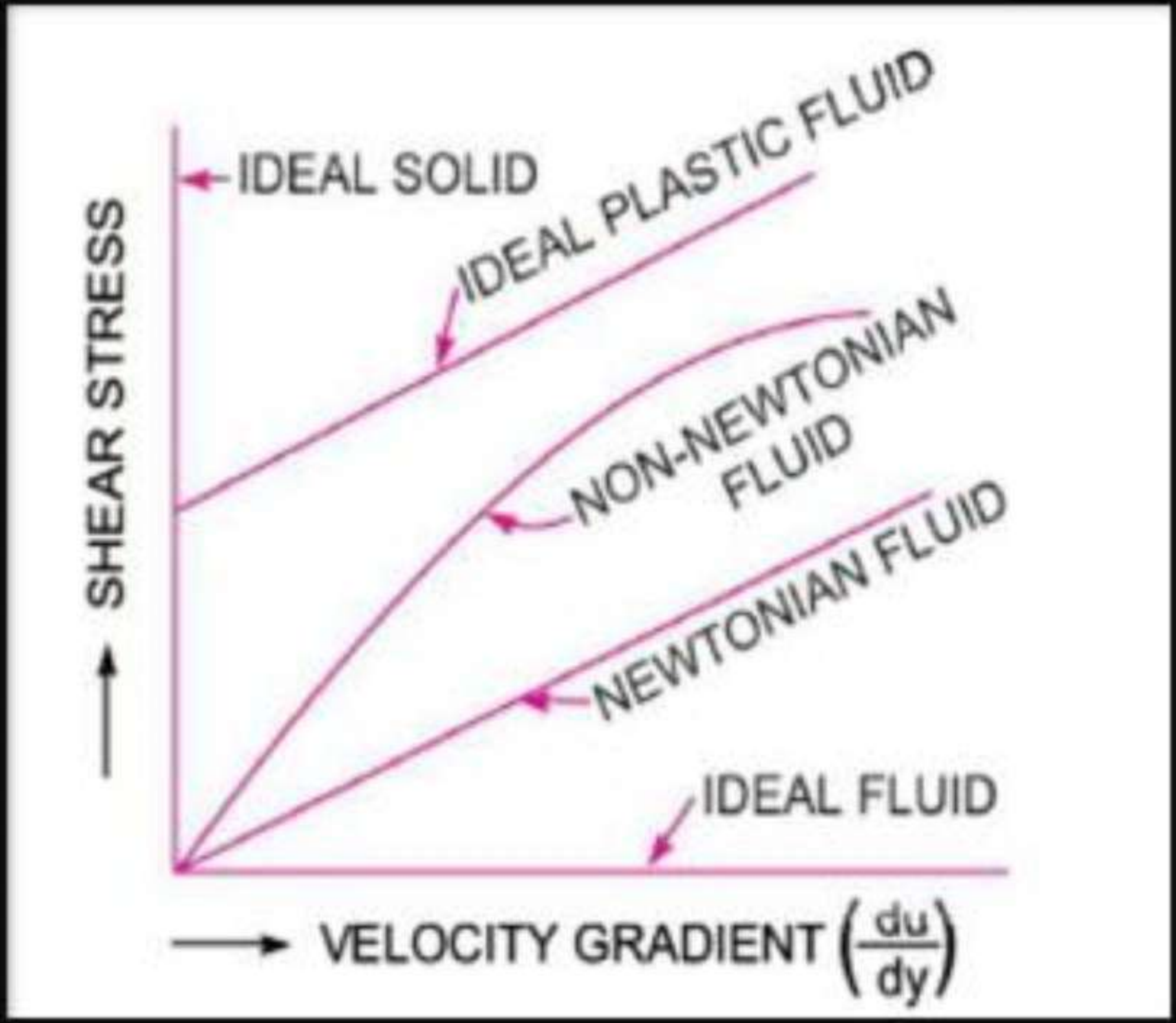
1. REAL FLUID: A fluid, which possess viscosity is known as real fluid. All the fluids, in actual practice are real fluids.

❖Example : Air, water, kerosene, petrol etc.

$(\mu = 0, \tau = 0)$

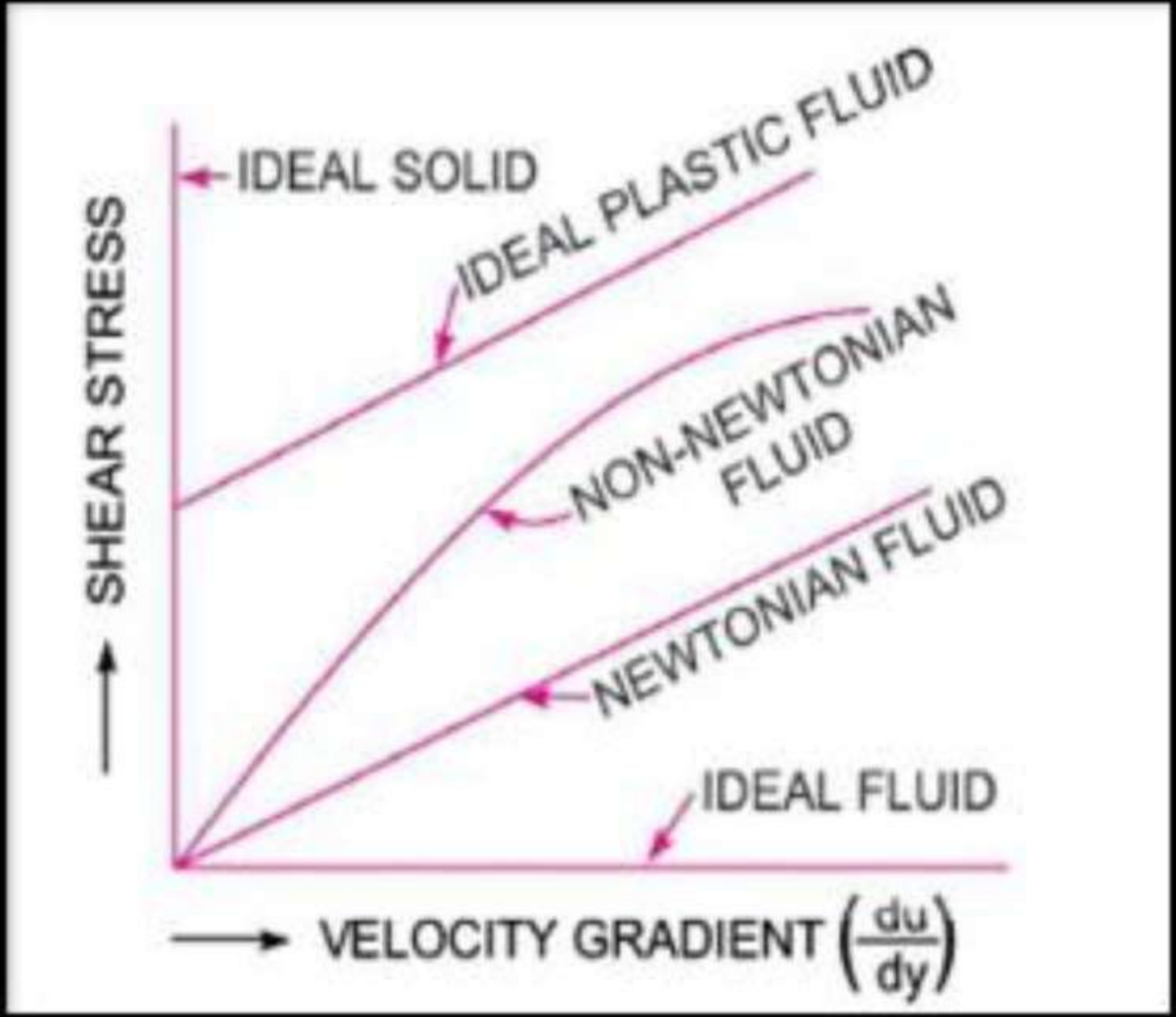
2. IDEAL FLUID:- Incompressible fluid having zero viscosity is called ideal fluid(τ = 0).

$$\boxed{\tau = \mu \cdot \frac{dy}{dy}}$$



3. NEWTONIAN FLUID:

- All the fluids which obey Newton's law of viscosity are known as Newtonian fluids.
- There is a linear relation between magnitude of τ and $\frac{d\theta}{dt}$.
- Example : Air, water, kerosene, petrol etc.



- $\tau = \mu\frac{du}{dy}$ Or $\tau = \mu\frac{d\theta}{dt}$
- $\mu = \tau/(\frac{d\theta}{dt})$

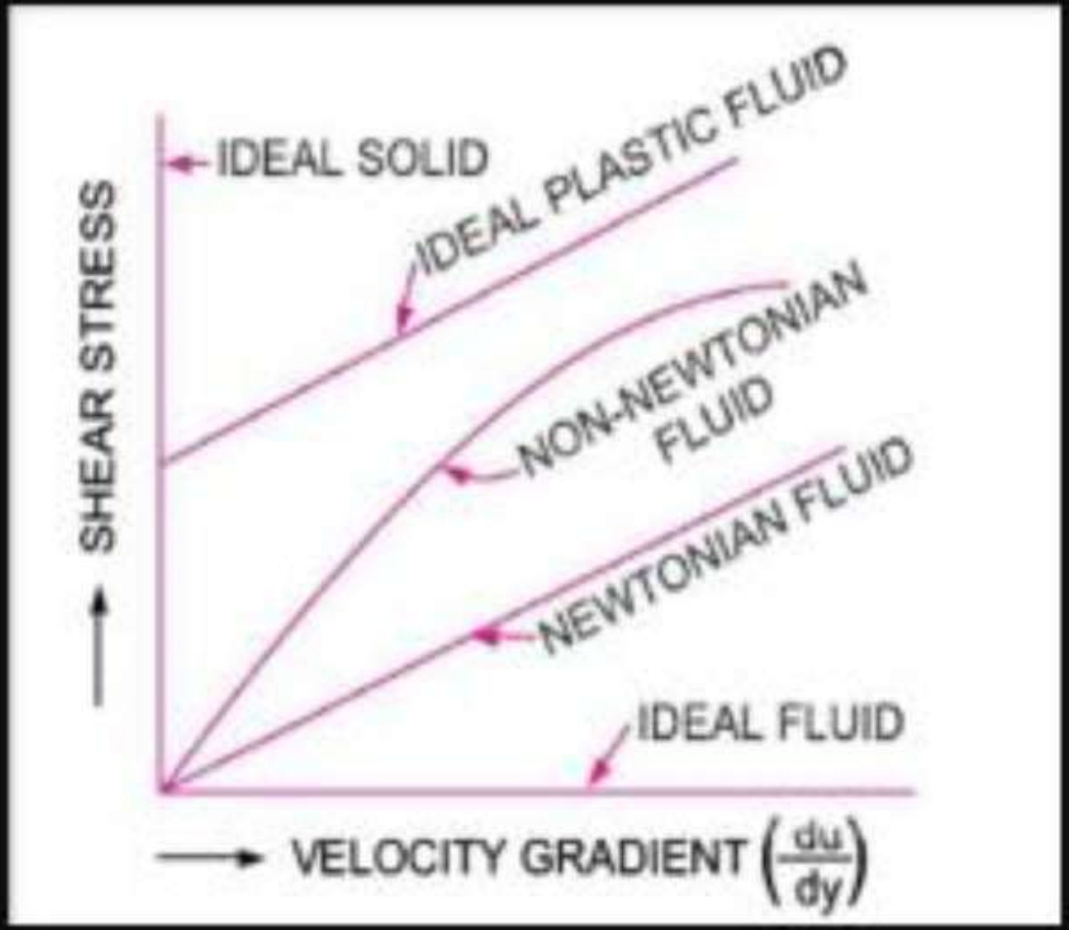
4.NON-NEWTONIAN FLUID:-

$\boxed{\tau \propto \frac{du}{dy}}$

❖The fluids which do not follow Newton's law viscosity are known as Non-Newtonian Fluid.

❖Example : Blood, paint, mud etc.

❖There is a non-linear relation between magnitude of τ and $\frac{d\theta}{dt}$.

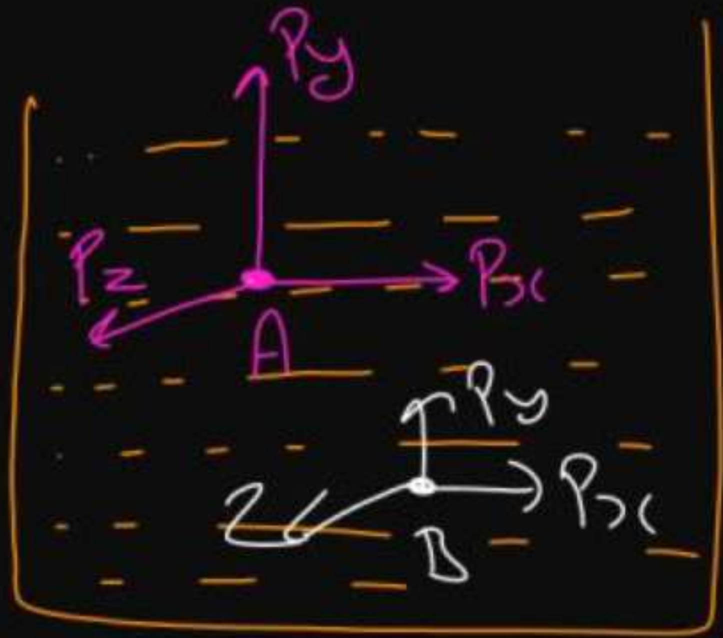


5. **ELASTIC SOLID:-** may be represented by vertical line.

Pascal's Law Statement

Statement: Pressure at a point in fluid at rest is same in all the directions.

$P_x = P_y = P_z$



$P_x = P_y = P_z$

Applications of Pascal's law

- Hydraulic lift
- Hydraulic Jacks
- Hydraulic brakes
- Hydraulic pumps

Derivation : Pascal's Law

Let us consider a wedge shape fluid element whose thickness is unity(1).

$\Sigma F_x = 0$ $\quad \xrightarrow{+ve} \quad \xleftarrow{-ve}$

$P_x \cdot dy - P \cdot ds \cdot \cos\theta = 0$

$P_x \cdot dy = P \cdot ds \cos\theta$

$P_x \cdot \cancel{dy} = P \cdot \cancel{dy}$

$\boxed{P_x = P}$ ---- (i)

$\Sigma F_y = 0$ $\quad \uparrow(+ve) \quad \downarrow(-ve)$

$P_y \cdot dx - P \cdot ds \sin\theta - W$

$P_y \cdot dx = P \cdot ds \cdot \sin\theta + \rho g \cancel{\frac{dx\,dy}{2}}^{\,0}$

$P_y \cdot dx = P \cdot ds \sin\theta$

$P_y \cdot \cancel{dx} = P \cdot \cancel{dx}$

$\boxed{P_y = P}$ — (ii)

$W = mg$ $\quad [m = \rho \cdot V]$

$= \rho \cdot V \cdot g$

$W = \rho g \frac{dx\,dy}{2}$

from eqn (i) & (ii)

$\boxed{P_x = P_y}$

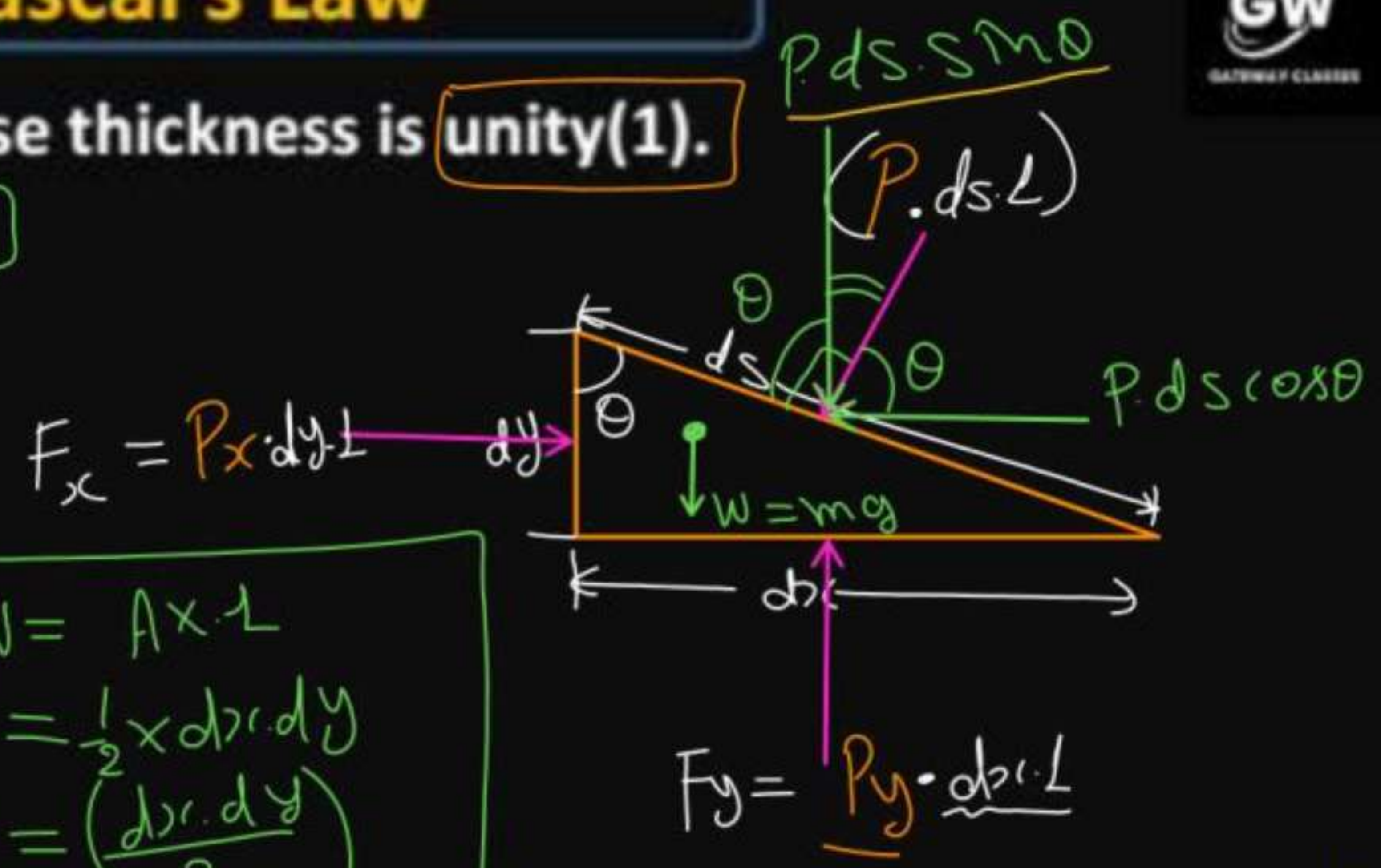
$$\boxed{P_x = P_y = P_z}$$

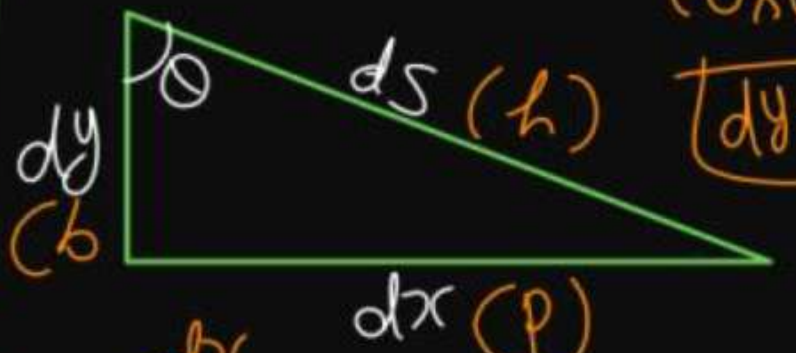
10 marks

$V = A \times 1$

$= \frac{1}{2} \times dx \cdot dy$

$= \left(\frac{dx \cdot dy}{2}\right)$





$\cos\theta = \frac{dy}{ds}$

$\boxed{dy = ds\cos\theta}$

$\sin\theta = \frac{dx}{ds}$

$\boxed{dx = ds\sin\theta}$

Example: Car's weight = 16,000 N, Plunger area = 50 cm², Ram area = 4000 cm². What is input force F_1 ?

$$P_1 = P_2$$

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

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

$$F_1 = \frac{50}{4000} \times 16000$$

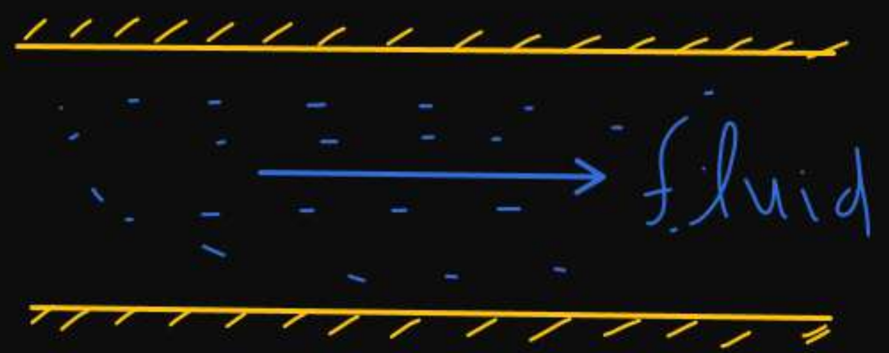
$$\boxed{F_1 = 200\,N}$$ Ans

$A_2 = 4000\,cm^2$ $\quad A_1 = 50\,cm^2$

$A_2 = \frac{\pi}{4} d_2^2$ $\quad A_1 = \frac{\pi}{4} d_1^2$

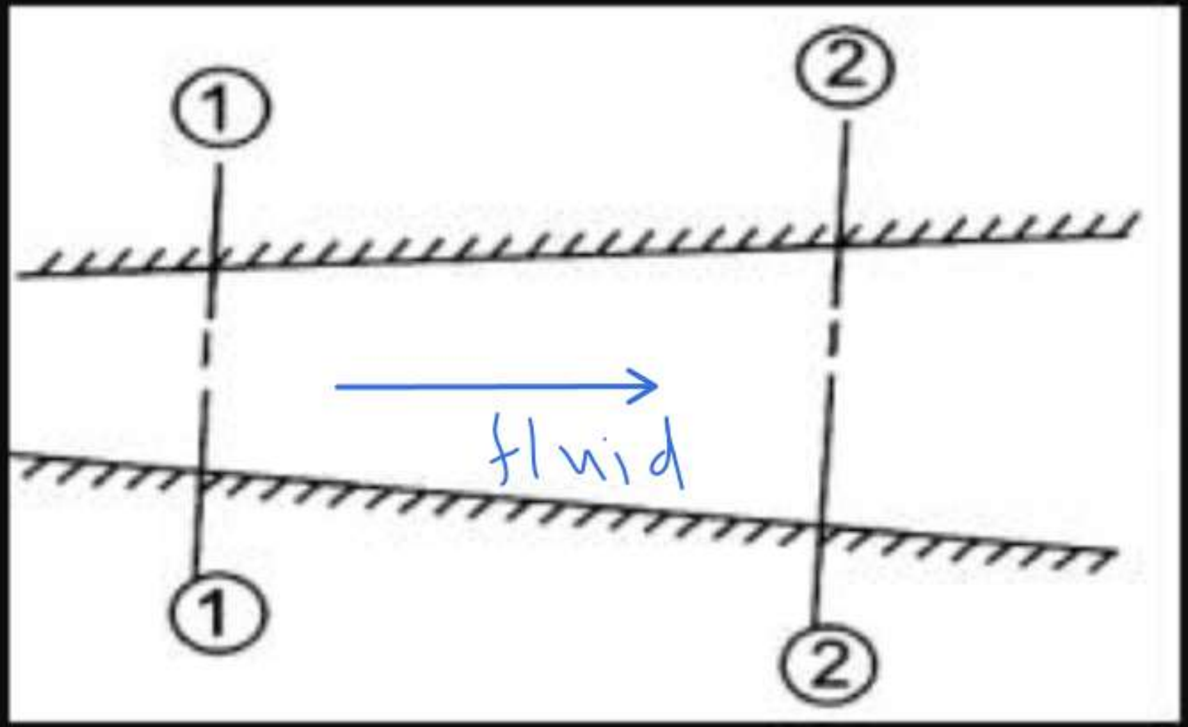
CONTINUITY EQUATION

- 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 ($\frac{m^3}{s}$) = $\frac{AL}{s}$ = A V [V = velocity]
- Flow Rate → mass flow rate ($\frac{kg}{s}$) = $\frac{\rho AL}{s}$ = ρA V
- This Continuity Equation is applicable for the compressible as well as In-compressible fluids .

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 eqn is valid for any fluid

❖ If the fluid is In-compressible, i.e. water then $\rho_1 = \rho_2$ and continuity equation becomes

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

This eqn is valid for Incompressible fluid i.e. liquid

Numerical 4.6 *The diameters of a pipe at the sections 1 and 2 are 10 cm and 15 cm respectively. Find the discharge through the pipe if the velocity of water flowing through the pipe at section 1 is 5 m/s. Determine also the velocity at section 2.*

Sol^n

Discharge, $Q = A_1 V_1 = A_2 V_2$

$$Q = A_1 V_1 = \frac{\pi}{4} d_1^2 \times V_1$$

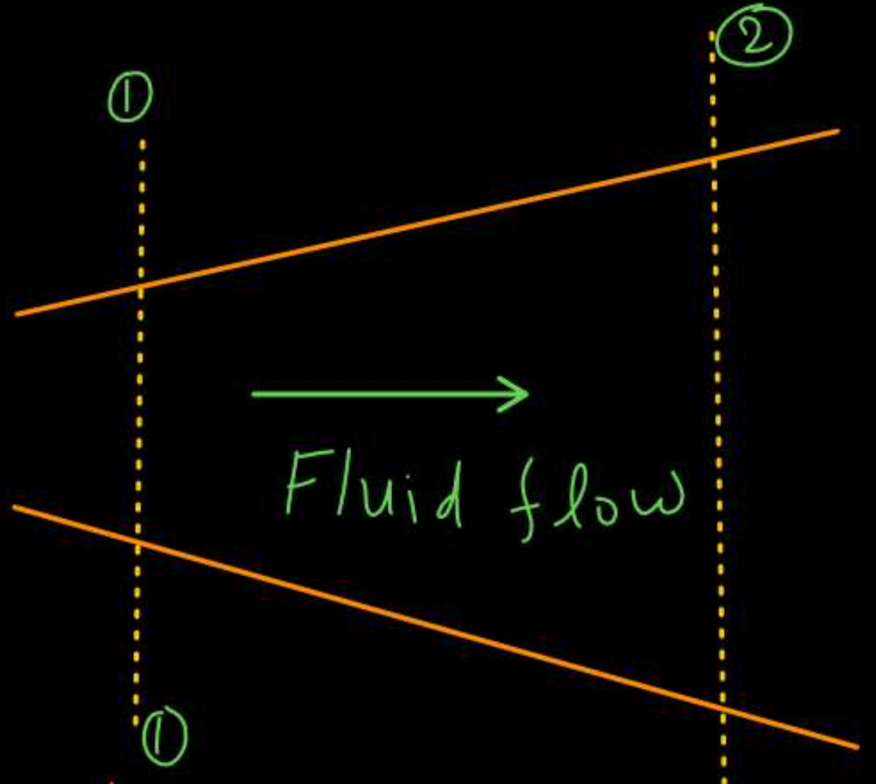
$$= \frac{\pi}{4} (0.1)^2 \times 5$$

$$\Rightarrow \boxed{Q = 0.03925 \ m^3/s} \text{ Ans}$$

$$A_1 V_1 = A_2 V_2 \Rightarrow \cancel{\frac{\pi}{4}} d_1^2 \times V_1 = \cancel{\frac{\pi}{4}} d_2^2 \times V_2$$

$$(0.1)^2 \times 5 = (0.15)^2 \times V_2$$

$$\Rightarrow \boxed{V_2 = 2.22 \ m/s} \text{ Ans}$$



$d_1 = 10$ cm $= 0.1$ m

$V_1 = 5$ m/s

$Q_1 = A_1 V_1 = ?$

$d_2 = 15$ cm $= 0.15$ m

$V_2 = ?$

FUNDAMENTALS OF MECHANICAL ENGINEERING (FME)

UNIT- 4 : Introduction to Fluid Mechanics and Applications

AKTU : Syllabus

Introduction:

- Fluids properties, pressure, density, dynamic and kinematic viscosity, specific gravity
- Newtonian and Non-Newtonian fluid
- Pascal's Law and Continuity Equation

- Working principles of hydraulic turbines (Pelton Wheel and Francis)& pumps (Centrifugal and Reciprocating) and their classifications and hydraulic lift.

Hydraulic Machines

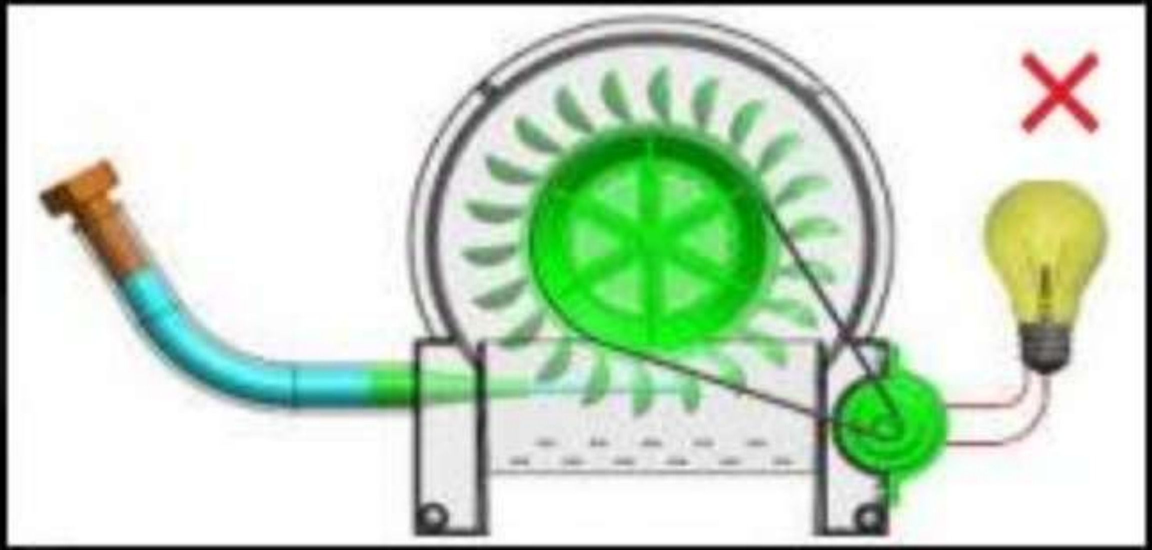
- Hydraulic machines are defined as those machines which convert either *hydraulic energy* into *mechanical energy* or *mechanical* energy into *hydraulic energy.*

- Hydraulic Energy- Energy possessed by water.

- Mechanical Energy- power produced at shaft of turbine.

Turbines

- The **hydraulic machines** which converts the hydraulic energy into mechanical energy, are called as **turbines**.



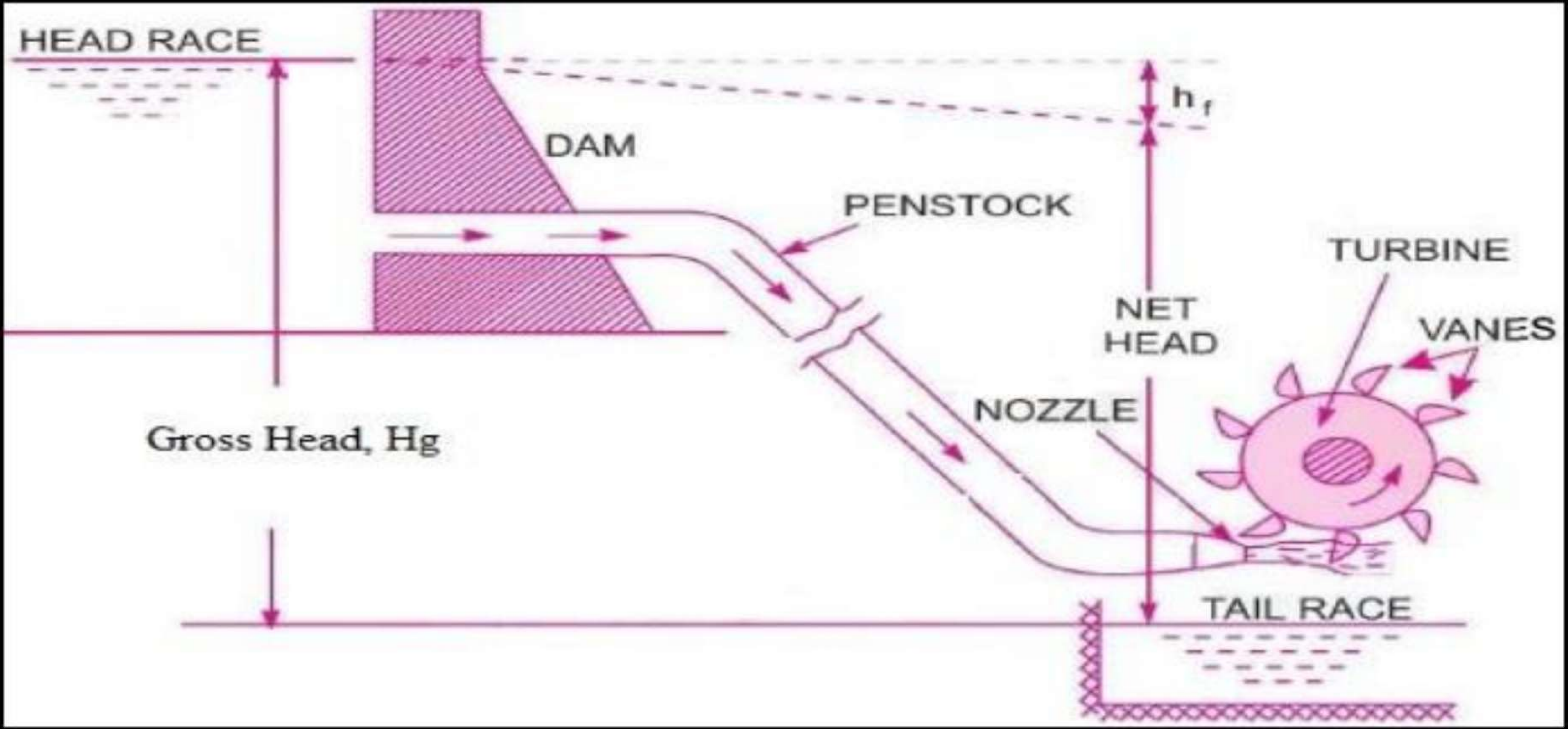
Pumps

- The **hydraulic machines** which converts mechanical energy into hydraulic energy , are called as **pump**.

Turbine

- 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*.

General Layout of Hydro-electric power plant



Classification of turbine

The turbines are classified in the following ways:-

1. According to the type of energy available at inlet

(a) Impulse turbine (b) Reaction turbine

❖ If at the inlet of the turbine , only kinetic energy, the turbine is known as *impulse turbine*.
e.g. Pelton Turbine.

❖ If at the inlet of the turbine, water possesses kinetic energy as well as pressure energy, the turbine is known as *reaction turbine*.
e.g. Francis turbine, Kaplan turbine.

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

a)Tangential flow turbine (e.g. Pelton Turbine)

b)Radial flow turbine (e.g. Francis Turbine)

c)Axial flow turbine (e.g. Kaplan Turbine)

d)Mixed flow turbine (e.g. Modern FrancisTurbine)

3. According to head available at the inlet of turbine

a) High head turbine e.g. P.T.

b) Medium head turbine e.g. F.T.

c)Low head turbine e.g. K.T

4. According to the specific speed of turbine

a)Low specific speed turbine e.g. P.T.

b) Medium specific speed turbine e.g. F.T.

c)High specific speed turbine e.g. K.T

5. According to the position of shaft of turbine

a) Horizontal shaft turbine

b) Vertical shaft turbine

(Pelton turbine has horizontal shaft whereas the rest have vertical shaft)

6. According to name of originator

a) Pelton Turbine(Pelton Wheel)

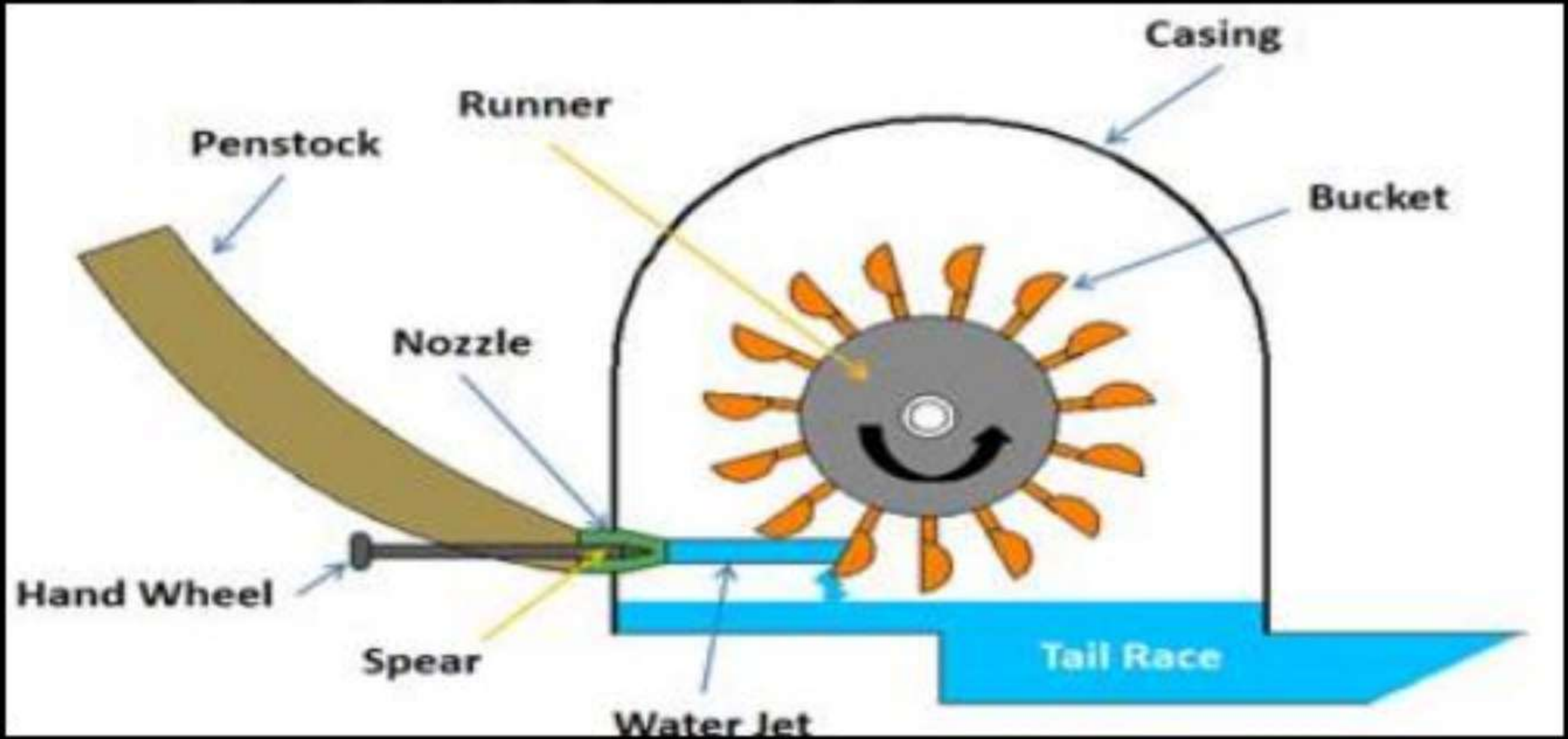
b) Francis Turbine

c) Kaplan Turbine

Impulse Turbine (Pelton)

Main parts of Impulse turbine(Pelton) are :-

1. Nozzle and flow regulating Arrangement (Spear)
2. Runner and buckets
3. Casing
4. Breaking jet



1. Nozzle and Flow Regulating Arrangement (Spear)

- Nozzle is used to increase the kinetic energy of the water that is going to strike the buckets or vanes attached to the runner.
- The quantity of water that strikes the buckets is controlled by spear. The spear is installed inside the nozzle and regulates the flow of water that is going to strike on the vanes of the runner. A nozzle containing spear is shown in the figure .
- When the spear is move backward the rate of flow of water increases and when it is pushed forward the rate of flow of water decreases.

2. Runner and Buckets

- A wheel of the turbine consist of series of buckets/blades/vanes mounted on its periphery.

- The buckets are designed in such a way that the jet of water strikes the buckets, deflected through 160 degree to 170 degree.

- The buckets of the Pelton turbine are made up of **cast iron, cast steel bronze or stainless steel.**

3. Casing:

The outer covering of this turbine is called casing. The Pelton turbine with the casing is shown in the figure.

- It is used to avoid accident and prevents the splashing of water.
- It does not perform any hydraulic function.
- The pressure throughout the turbine from inlet to outlet is atmospheric in case Impulse turbine.
- **Cast iron or fabricated steel plates** are used to make the casing of the Pelton Turbine.

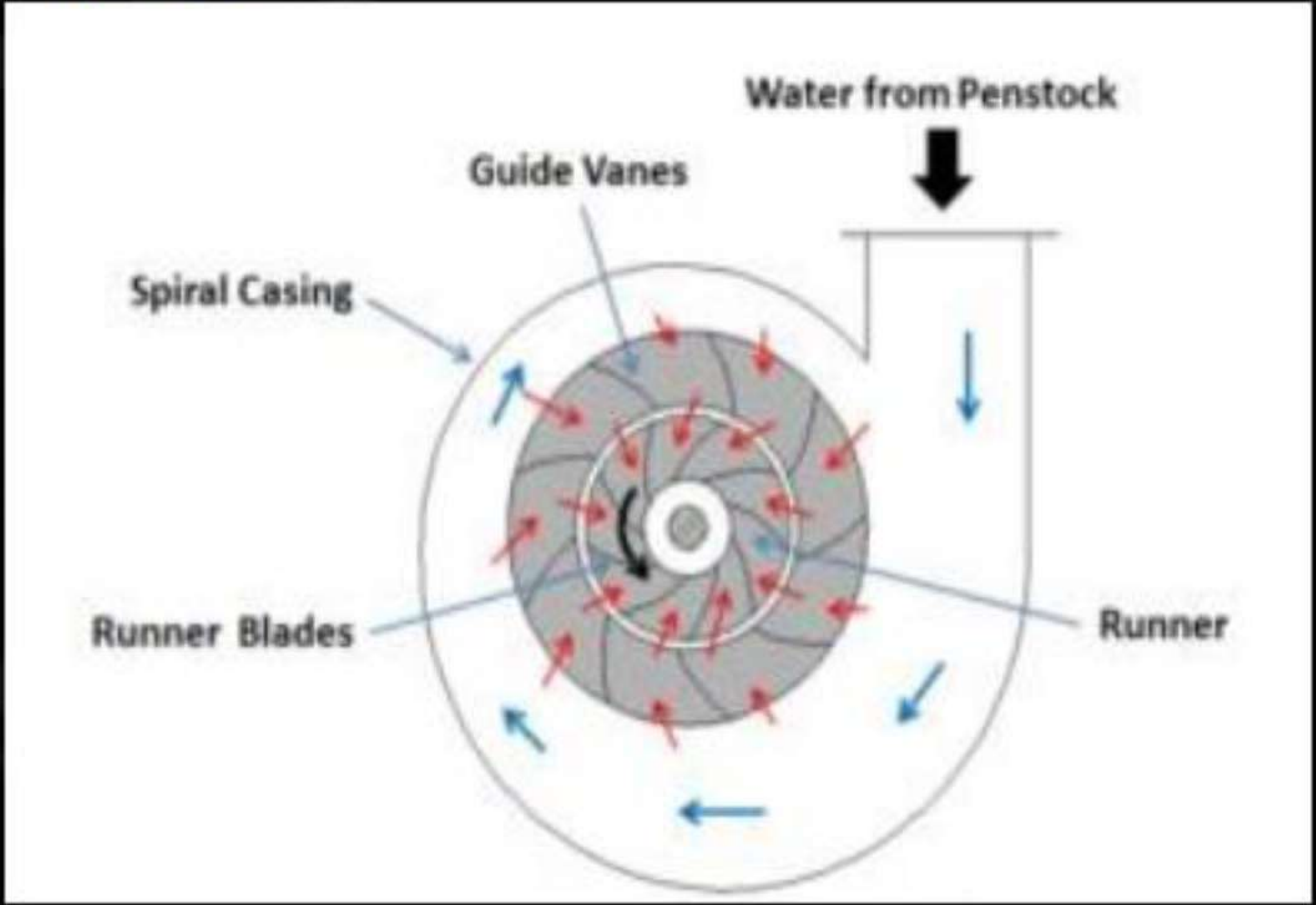
4. Breaking jet

- When the jet of water is completely closed by pushing the spear in the forward direction than the amount of water striking the runner becomes zero.
- But still, the runner keeps moving due to the inertia of the runner.
- In order to stop the runner in the shortest possible time, a small nozzle is provided which directs the jet of water at the back of the vanes.
- This jet of water used to stop the runner of the turbine is called breaking jet.

Reaction Turbine(Francis)

Main parts of reaction Turbine(Francis) are :-

1. Spiral Casing
2. Guide Vanes
3. Runner Blades
4. Draft tube



1. Spiral Casing

- Spiral casing is the inlet medium of water to the turbine.
- The water flowing from the reservoir or dam is made to pass through this pipe with high pressure.
- The blades of the turbines are circularly placed, which mean the water striking the turbines blades should flow in the circular axis for efficient striking.
- So the spiral casing is used, but due to circular movement of the water, it looses its pressure.
- To maintain the same pressure the diameter of the casing is gradually reduced, so as to maintain the pressure uniform, thus uniform momentum or velocity striking the runner blades.

2. Guide Vanes

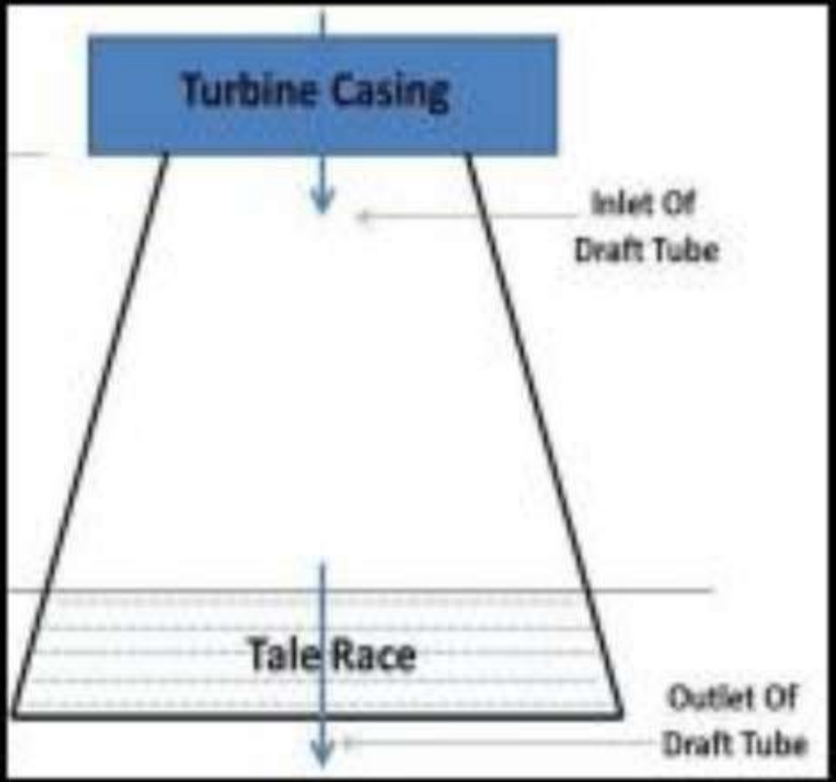
- The guide vanes allow the water to strike the fixed blades on the runner without shock at inlet.
- Guide vanes are not stationary, they change their angle as per the requirement to control the angle of striking of water to turbine blades to increase the efficiency.
- They also regulate the flow rate of water into the runner blades thus controlling the power output of a turbine according to the load on the turbine.

3. Runner Blades

- These are the fixed blades mounted on its periphery of runner.
- The performance and efficiency of the turbine dependent on the design of the runner blades. I

4. Draft tube

- The pressure at the exit of the runner of Reaction Turbine is generally less than atmospheric pressure.
- The water at exit cannot be directly discharged to the tail race.
- A tube or pipe of gradually increasing area is used for discharging water from the exit of turbine to the tail race.
- This tube of increasing area is called Draft Tube.
- One end of the tube is connected to the outlet of runner while the other end is sub-merged below the level of water in the tail-race.
- Pressure head is increased by decreasing the exit velocity.
- Overall efficiency and the output of the turbine can be improved.



Applications of Francis Turbine

- Francis turbine is the most widely used turbine in hydro-power plants to generate electricity.
- Mixed flow turbine is also used in irrigation water pumping sets to pump water from ground for irrigation.
- It is efficient over a wide range of water head and flow rate.
- It is most efficient hydro-turbine we have till date.

Pump

- The hydraulic machine which converts *Mechanical energy into Hydraulic energy* is known as pump.

- The hydraulic energy is in the form of *Pressure Energy*.

- If the mechanical energy is converted into pressure energy by means of centrifugal force acting on the fluid, the hydraulic machine is called *Centrifugal Pump*.

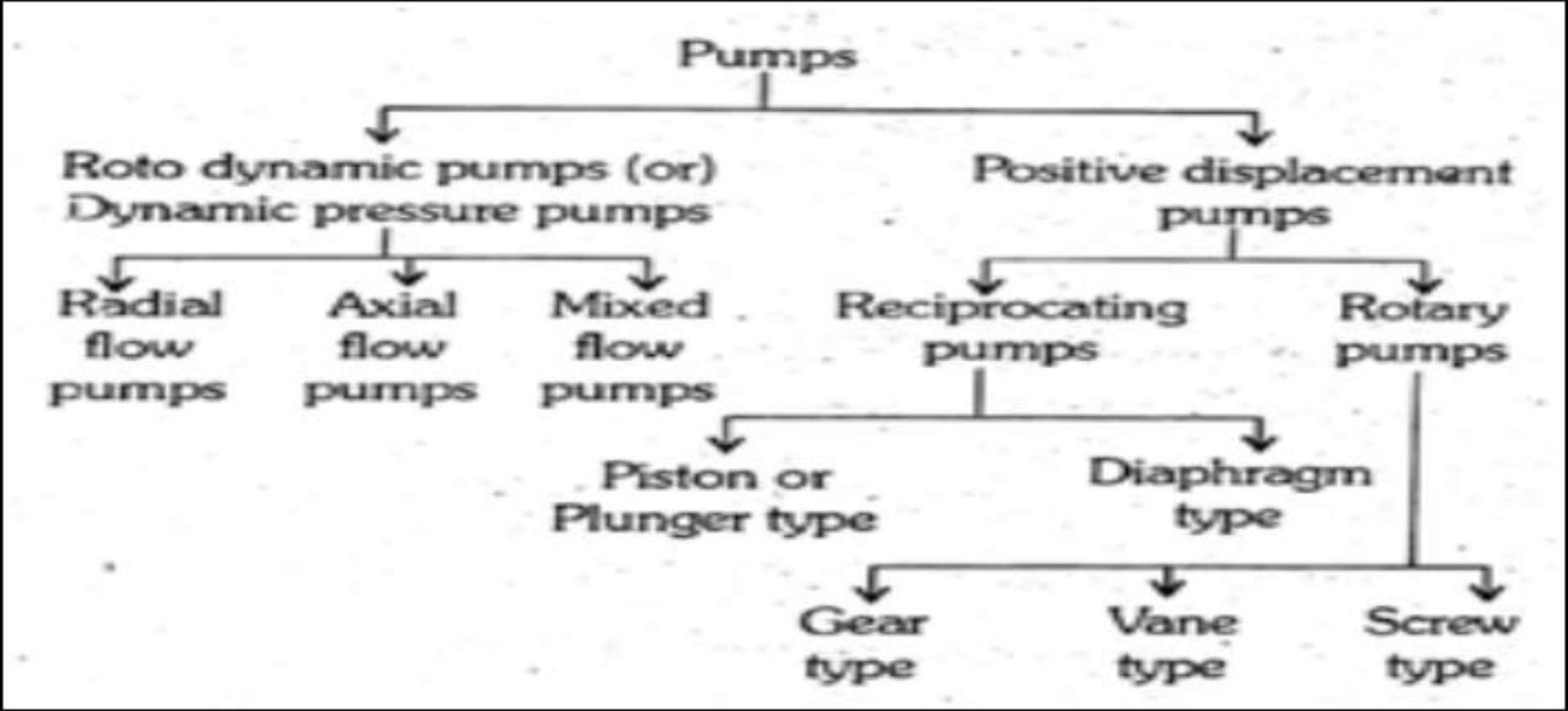
- The centrifugal pump works on the principle of *forced vortex flow.*

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

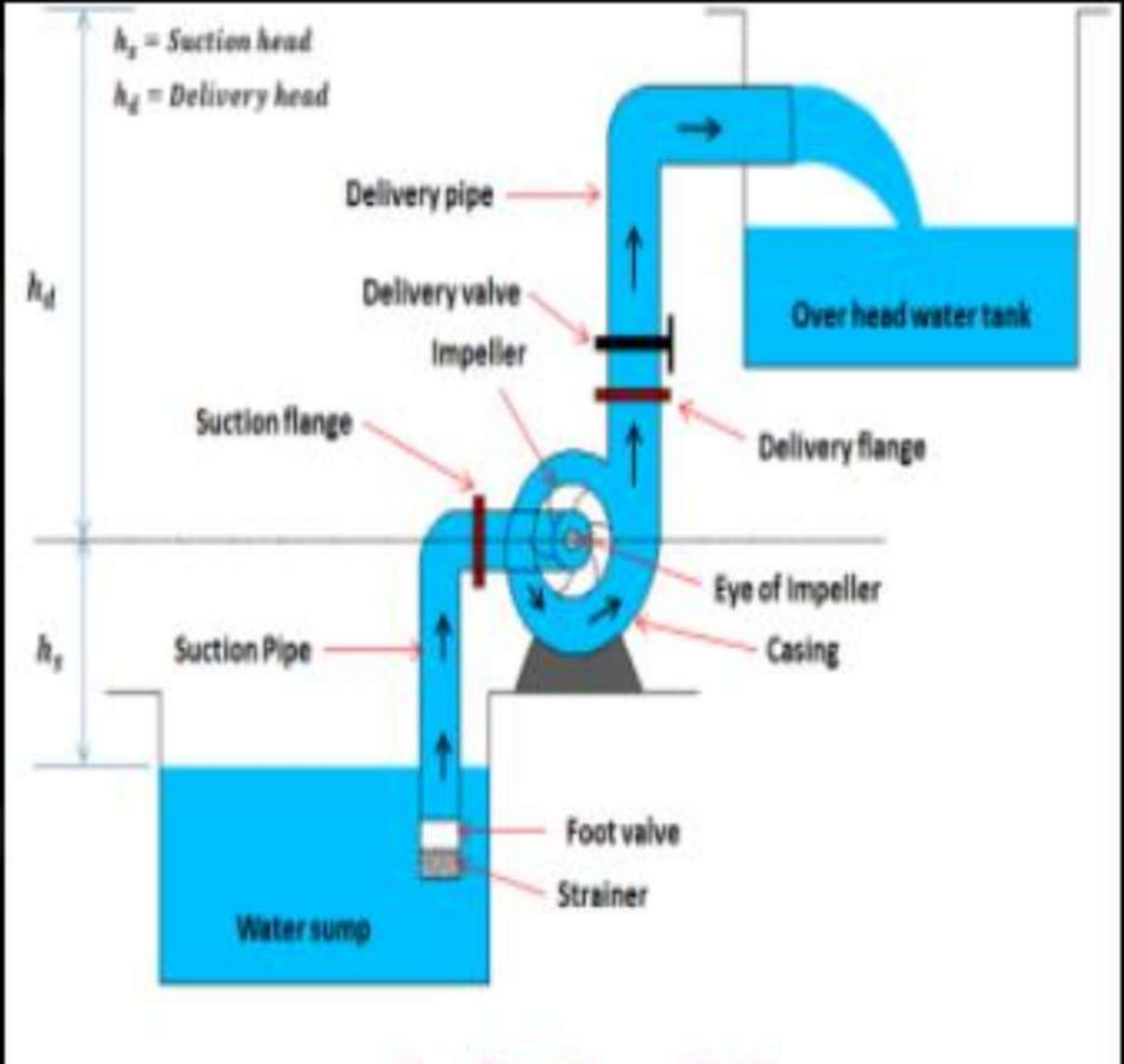
Classification of Pump



Centrifugal Pump

Main parts of a C.P. are :-

1. Impeller
2. Casing
3. Suction pipe with foot valve and a strainer.
4. Delivery pipe



Centrifugal Pump Working

- Centrifugal pump is a mechanical device designed to move a fluid by means of the transfer of rotational energy from one or more driven rotors, called impellers. Fluid enters the rapidly rotating impeller along its axis and is cast out by centrifugal force along its circumference through the impeller's vane tips

- Centrifugal pumps are used to induce flow or raise a liquid from a low level to a high level. These pumps work on a very simple mechanism. A centrifugal pump converts rotational energy, often from a motor, to energy in a moving fluid.

- The two main parts that are responsible for the conversion of energy are the impeller and the casing.
- The impeller is the rotating part of the pump and the casing is the airtight passage which surrounds the impeller.
- In a centrifugal pump, fluid enters into the casing, falls on the impeller blades at the eye of the impeller, and is whirled tangentially and radially outward until it leaves the impeller into the diffuser part of the casing.
- While passing through the impeller, the fluid is gaining both velocity and pressure

Applications of Centrifugal Pumps:

Centrifugal pumps are the most popular choice for fluid movement some of the major sectors that make use of these pumps are :

1.Oil & Energy - pumping crude oil, slurry, mud; used by refineries, power generation plants

2.Industrial & Fire Protection Industry - Heating and ventilation, boiler feed applications, air conditioning, pressure boosting, fire protection sprinkler systems.

3.Waste Management, Agriculture & Manufacturing - Wastewater processing plants, municipal industry, drainage, gas processing, irrigation, and flood protection

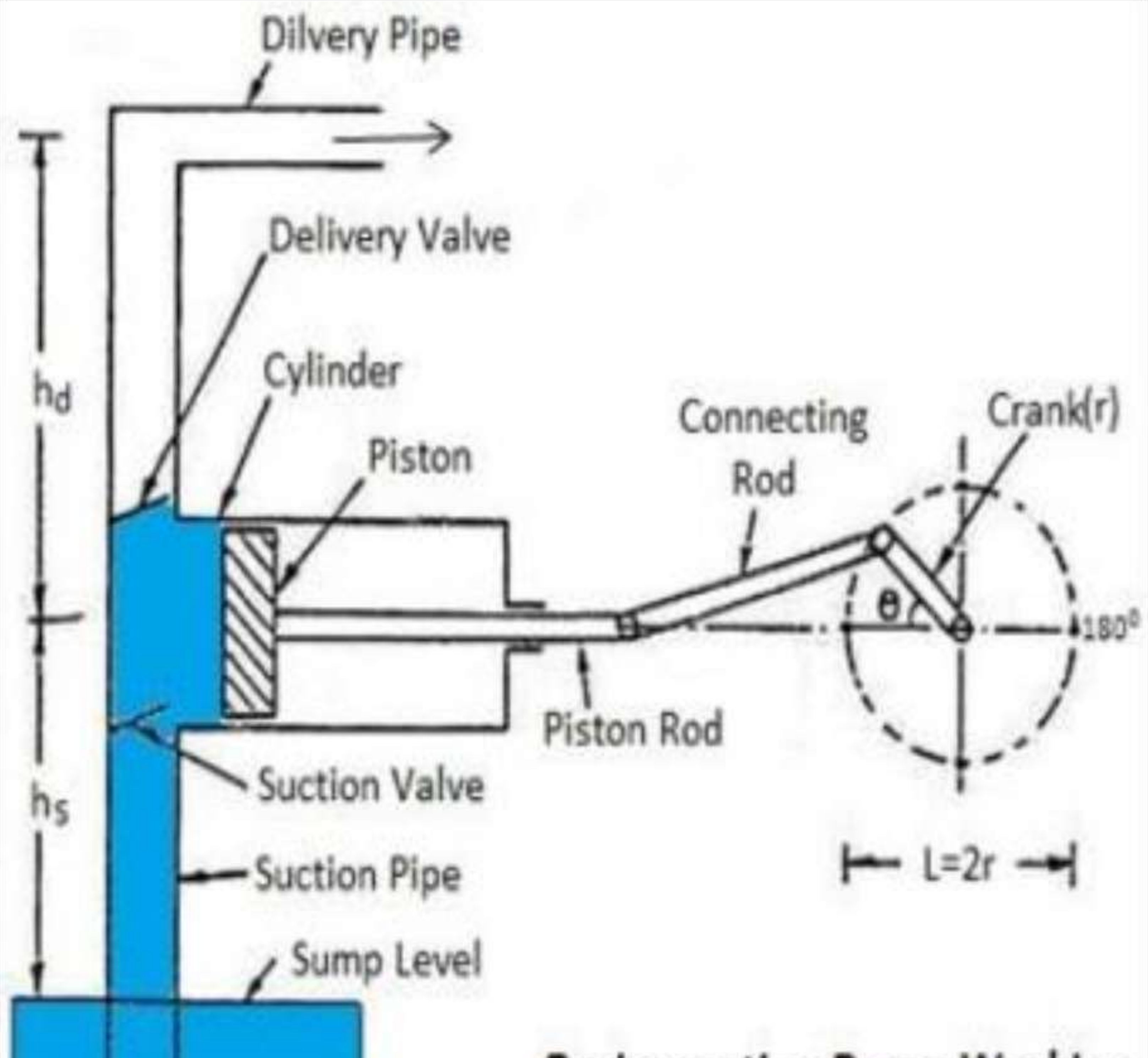
4.Pharmaceutical, Chemical & Food Industries - paints, hydrocarbons, petrochemical, cellulose, sugar refining, food and beverage production

5.Various industries (Manufacturing, Industrial, Chemicals, Pharmaceutical, Food Production, Aerospace etc.) - for the purposes of cryogenics and refrigerants.

Reciprocating Pump

The main components of R.P. are:

- Water Sump
- Strainer
- Suction Pipe
- Suction Valve
- Cylinder
- Piston and Piston rod
- Crank and Connecting rod
- Delivery valve
- Delivery pipe



Reciprocating Pump Working

- It is a machine that converts mechanical energy into hydraulic energy. Reciprocating pumps are in use where a certain quantity of fluid (mostly sump) has to be transported from the lowest region to the highest region by the application of pressure.

Water Sump: It is the source of water. From the sump, water is to be transported to the delivery pipes by the usage of the piston.

Strainer: It acts as a mesh that can screen all the dirt, dust particles, etc. from the sump. If there is no strainer, then the dirt or dust also enters into the cylinder which can jam the region and affects the working of the pump.

Suction Pipe: The main function of the suction pipe is to collect the water from the sump and send it to the cylinder via a suction valve. The suction pipe connects the water sump and the cylinder.

Suction Valve: It is a non-return valve which means it can take the fluid from the suction pipe and send it to the cylinder but cannot reverse the water back to it. In the sense, the flow is unidirectional. This valve opens only during the suction of fluid and closes when there is a discharge of fluid to outside.

Cylinder: It is a hollow cylinder made of cast iron or steel alloy and it consists of the arrangement of piston and piston rod.

Piston and Piston rod: For suction, the piston moves back inside the cylinder and for discharging of fluid, the piston moves in the forward direction.
The Piston rod helps the piston to move in a linear direction i.e. either the forward or the backward directions.

Crank and Connecting rod: For rotation, the crank is connected to the power source like engine, motor, etc. whereas the connecting rod acts as an intermediate between the crank and piston for the conversion of rotary motion into linear motion.

Delivery Pipe: The function of the delivery pipe is to deliver the water to the desired location from the cylinder.

Delivery valve: Similar to the suction valve, a delivery valve is also a Non-return valve. During suction, the delivery valve closes because the suction valve is in opening condition and during Discharge, the suction valve is closed and the delivery valve Is opened to transfer the fluid.
These are the various components of Reciprocating pump. Let's understand the working principle of it.

Working Principle of Reciprocating Pump:

When the power supply is given to the reciprocating pump, the crank rotates through an electric motor.

- The angle made by the crank is responsible for the movement of the piston inside the cylinder. By referring to the above diagram, the piston moves towards the extreme left of the cylinder when the crank meets position A i.e. $\theta=0$.
- Similarly, the piston moves towards the extreme right of the cylinder when the crank meets the position C i.e. $\theta=180$.
- A partial vacuum in the cylinder takes place when the piston movement is towards the right extreme position i.e. ($\theta=0$ to $\theta=180$.) and that makes the liquid enter into the suction pipe.
- This is due to the presence of atmospheric pressure on the sump liquid which is quite less than the pressure inside the cylinder. Therefore, due to the difference in pressure, the water enters into the cylinder through a non-return valve.

- The water which stays in the volume of the cylinder has to be sent to the discharge pipe via discharge valve and this can be done when the crank is rotating from C to A i.e. (θ=180 to θ=360) which moves the piston in the forward direction.
- Due to the movement of the piston in a forward direction, the pressure increases inside the cylinder which is greater than the atmospheric pressure.
- This results in the opening of the delivery valve and closing of the suction valve.
- Once the water comes into the delivery valve, it cannot move back to the cylinder because it is a unidirectional valve or non-return valve.
- From there, it enters into the delivery pipe so that it can be sent to the required position.
- Therefore, in this way, the water is sucked and discharged from the sump to the desired location through the piston inside the cylinder.

Types of Reciprocating Pump

1. According to the water being in contact with one side or both sides of the piston-

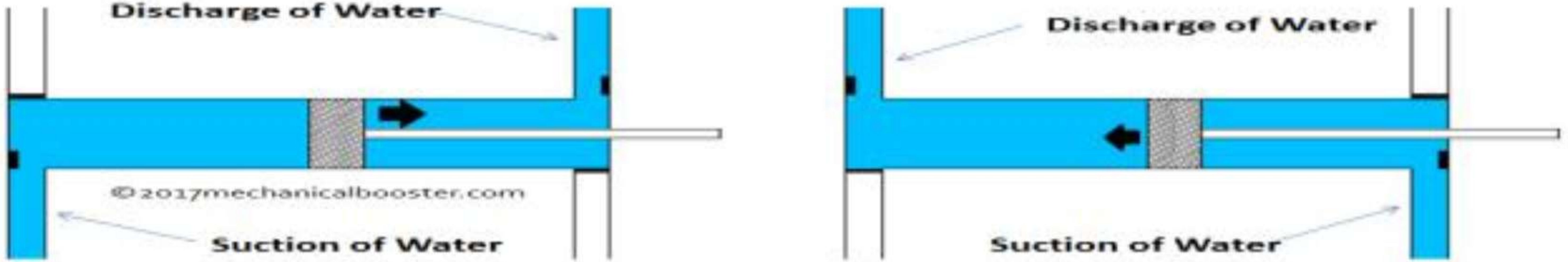
A. Single acting pump
B. Double acting pump

2. According to the number of cylinder provided

A. Single cylinder pump,
B. Double cylinder pump,
C. Triple cylinder pump.

Double acting R.P.

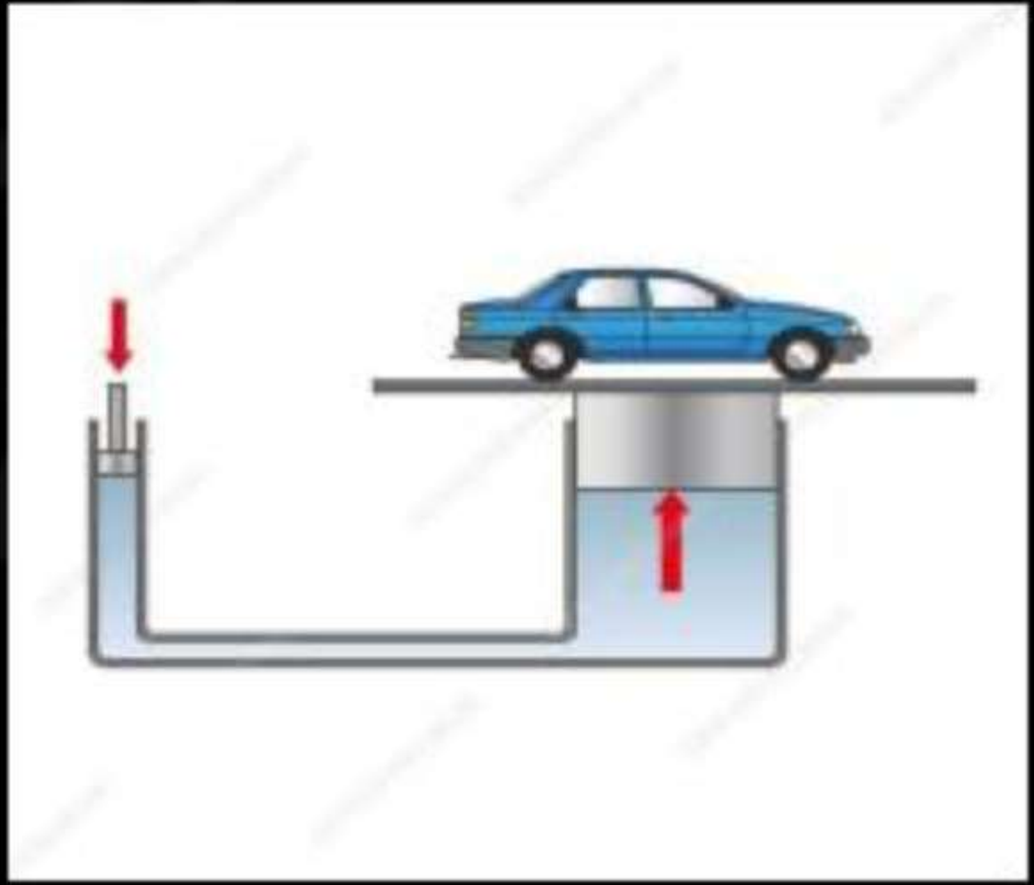
Single Acting Reciprocating Pump



Double Acting Reciprocating Pump

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.



Types of Hydraulic Lift

The Hydraulic Lifts are of two types-

1. Direct acting hydraulic lift

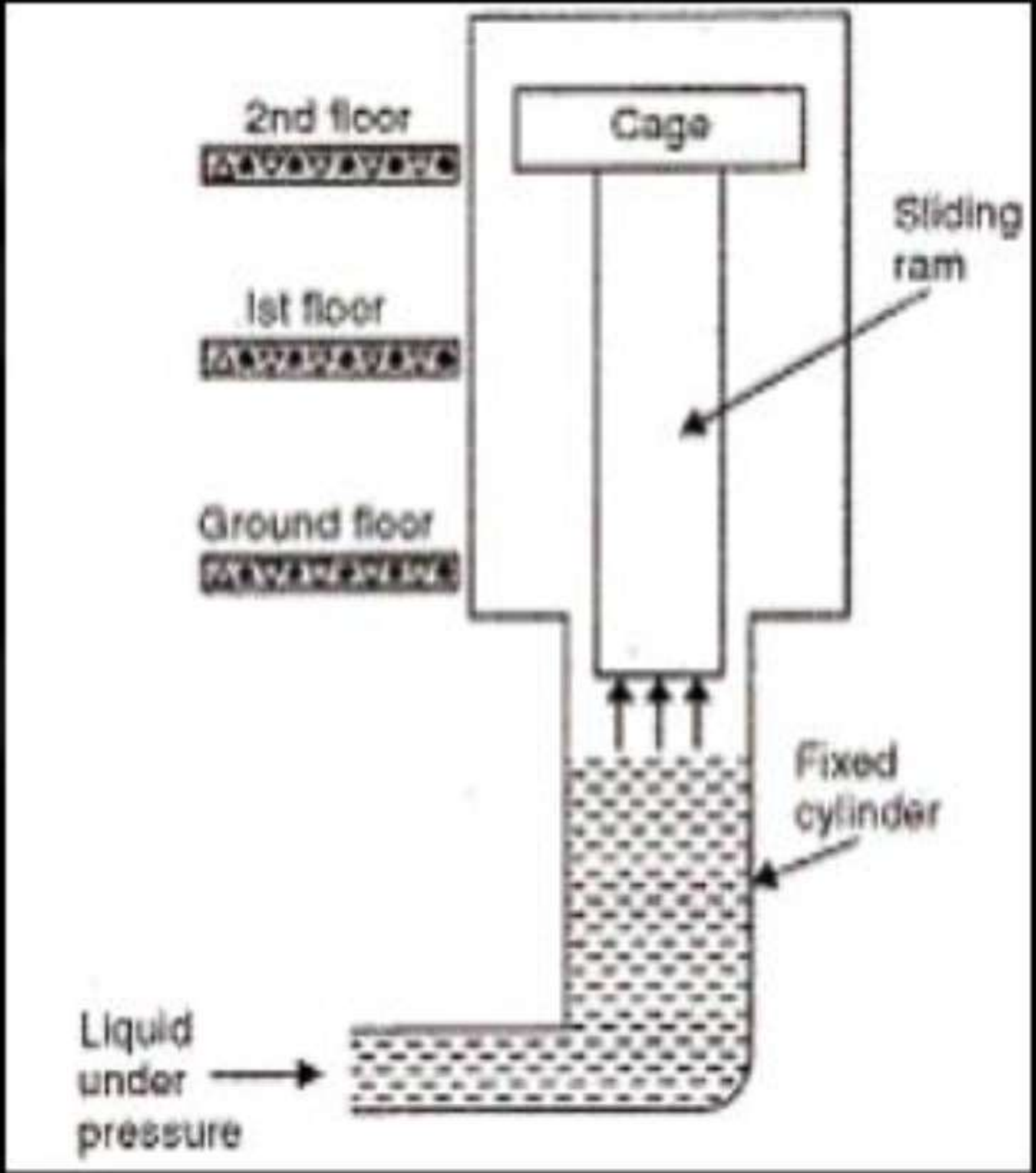
2. Suspended hydraulic lift

1.Direct Acting Hydraulic Lift

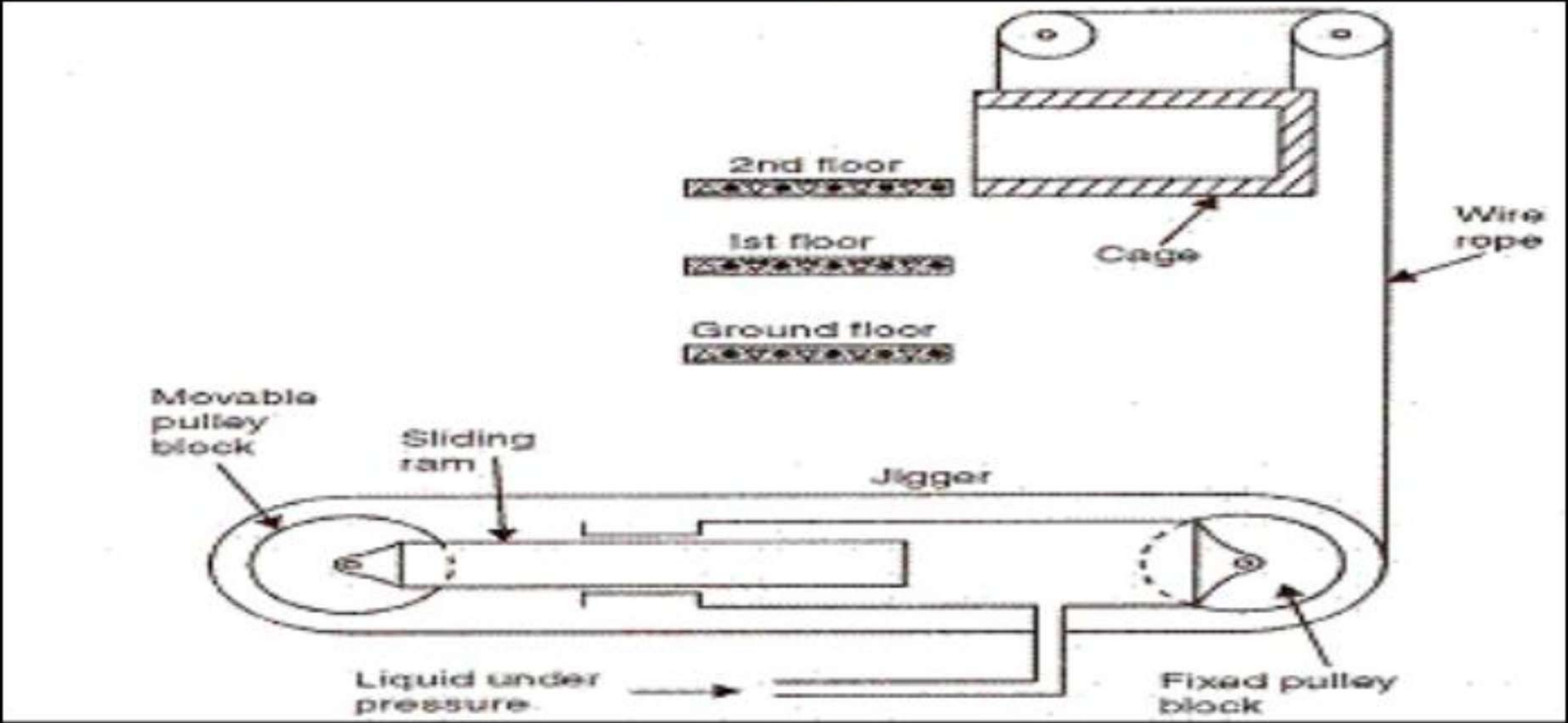
- It consists of a ram, sliding in the fixed cylinder.
- At the top of the sliding ram a cage is fitted.

- 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.



2. Suspended Hydraulic Lift



2. 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 end 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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