Chapter-1 (INTRODUCTION)

ART. 1. Fluid

A Fluid is a substance which continuously deforms underthe effect of shear stress.

OR

Fluid is a substance which does not resist a shear stress anddeforms under it. It has no definite shape but takes the shape of containing vessel.Its shape changes when the shearing force is applied over. It flows,therefore under the effect of the shearing force.

Examples of fluids are: water, oil, air, gases and vapours etc.

ART. 2. CLASSIFICATION OF FLUIDS:

Fluids are broadly classified in following two categories:

1. Liquids
2. Gases or Vapour

ART. 3. TYPES OF FLUIDS

The fluids may be classified into the following types:

[1] Ideal fluid
[2] Real fluid
[3] Newtonian fluid
[4] Non-Newtonian fluid
[5] Ideal plastic fluid
[6] Thixotropic substance.

[1] Ideal Fluid

A fluid, which is incompressible, has no viscosity and no shearingresistance is known as an ***ideal fluid*** or ***perfect fluid***.Such fluids do not exist innature and are, therefore, only imaginary fluids, as all the fluidswhich exist, have some viscosity.

[2] Real Fluids

Fluids which possess the properties such as viscosity,surface tension and compressibility are referred as real or practicalfluids.

- All the fluids, in actual practice, are real fluids.

[3] Newtonian Fluids

Fluid which do not obey the Newton's law of viscosity is known as non-Newtonian fluids.

OR

A real fluid in which the shear stress is not proportional to the rate of shear strain is known as a non-Newtonian fluid.

Mathematically,

$$\tau \, \alpha \frac{du}{dy} \quad \textbf{or} \quad \tau = \mu \frac{du}{dy} = \mu \left(\frac{du}{dy}\right)^{n=1}$$

τ = Viscous shear stress

du = Velocity difference between the upper and lower edge of lamina

dy = Thickness of the fluid lamina

μ = Viscosity

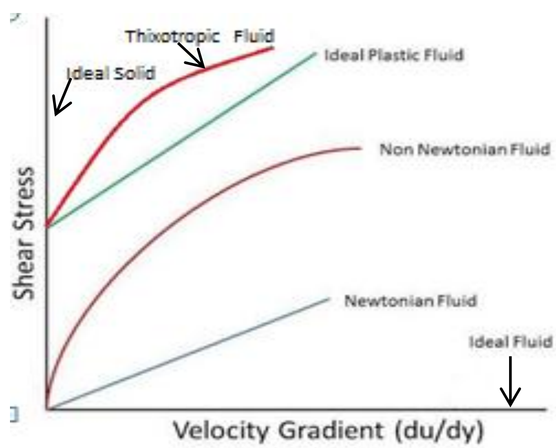
[4]Deal Plastic Fluid Or Bingham Fluid

A fluid, in which shear stress is more than the yield value and proportional to the rate of shear strain is known as ideal plastic fluid or Bingham fluid.

Shear stress = Yield stress $+\boldsymbol{\mu} \frac{\boldsymbol{du}}{\boldsymbol{dy}}$

[5] Thixotropic Substance

A substance, which is a non-Newtonian fluid, has a non-linear relationship between the shear stress and the rate of angular deformation, beyond an initial yield stress is called thixotropic substance.



ART. 4.HYDRAULICS

Hydraulics is that branch of engineering science which is based on experimental observation of water flow.

ART. 5. CONCEPT OF CONTINUUM

A continuous and homogenous fluid medium is called continuum.

ART. 6. PROPERTIES OF FLUIDS

- Density or Mass Density
- Weight Density or Specific Weight
- Specific Value
- Specific Gravity
- Viscosity
- Kinematic Viscosity
- Surface Tension

ART. 7. DENSITY OR MASS DENSITY

Density of fluid is defined as the ratio of mass of fluid to its volume.

$$\rho = \frac{Mass\ of\ Fluid}{Volume\ of\ Fluid} = \frac{m}{v}$$

ART. 8. WEIGHT DENSITY OR SPECIFIC WEIGHT

Weight density or specific weight of fluid is defined as the weight per unit volume.

$$w = \frac{Weight\ of\ Fluid}{Volume\ of\ Fluid}$$

$$w = \rho g$$

ART. 9. SPECIFIC VOLUME

Specific volume of a fluid is defined as the volume per unit mass of fluid.

$$v = \frac{1}{Mass\ Density} = \frac{1}{\rho}$$

ART. 10. SPECIFIC GRAVITY

Specific gravity is defined as the ratio of specific weight (or mass density) of the fluid to the specific weight of standard fluid (or mass density of standard fluid).

ART. 11. <u>VISCOSITY</u>

Viscosity of fluid is defined as to be that property of fluid which determines its resistance to shearing stress or shear deformation or angular deformation.

S.I. UNIT: $\mu = \frac{Newton-Second}{m^2}$

ART.12. <u>COHESION</u>

The property of the liquid by virtue of which the molecules of the liquid remain attached to each other is referred as cohesion.

ART. 13. <u>ADHESION</u>

The property of a liquid which enables it to adhere to another body with which it comes into contact is called adhesion.

Chapter-2 (PRESSURE AND ITS MEASUREMENT)

ART. 1. DIFFERENT RELATED TO PRESSURE

1.1 Pressure head of liquid

$$h = \frac{p}{w} = \frac{Intensity\ of\ pressure}{Specific\ Weight\ of\ Liquid}$$

ART. 2. ATMOSPHERIC PRESSURE

Atmospheric pressure is the normal pressure exerted by atmospheric air on all surfaces in contact with it.

$$\rho = 101.3KN/m^2 = 1.013 \times 10^5 N/m^2$$

ART. 3. GAUGE PRESSURE [P_{GAUGE}]

If the pressure to be measured by gauge is above atmospheric pressure, it is called positive gauge pressure.

Gauge pressure is defined as the pressure which is measured with the help of pressure measuring instrument, in which the atmospheric pressure is taken as datum i.e. atmospheric pressure on scale is marked as zero.

ART. 4. VACUUM PRESSURE

When pressure to be recorded is below atmosphere, it is called ***vacuum pressure***or***negative pressure*** this indicates the amount by which the recorded pressure is below atmospheric pressure.

ART. 5. ABSOLUTE PRESSURE

Absolute pressure is defined as the pressure measured above absolute zero of pressure. In other words, a pressure measured in a complete vacuum is called ***absolute pressure.***

ART. 6. PRESSURE MEASURING DEVICE

[A] Manometer

[B] Mechanical Gauges

ART. 7. MANOMETER

Manometers are of two types:

[1] Simple manometer or Open type manometers.

[2] Differential type of manometers.

ART. 8. SIMPLE MANOMETERS

The manometers which measure pressure at a point in a fluid contained in a vessel or pipe are called simple manometers.

A simple manometer consists of a glass tube having one of its ends connected to a point where pressure is to be measured and other end remains open to atmosphere.

Simple manometers are of following types:

(i) Piezometer Tube

(ii) U-Tube Manometer or Double Column Manometer.

(iii)Micromanometer or Single Column Manometer.

ART. 9. PIEZOETER TUBE

It is the simplest types of manometer. It is directly fitted to the pipe or container. Rise or height of liquid into the tube gives the pressure head of liquid.

ART. 10. U-TUBE MANOMETER

For measuring large gauge pressure, u-tube manometer is used. U-tube manometer may be regarded as the modification of piezometer tube. Actually, u-tube manometer consists of a glass tube bent in u-shape. One end of the tube is connected to a pipe or container having a fluid (a) whose pressure is to be measured while the other end is open to atmosphere.

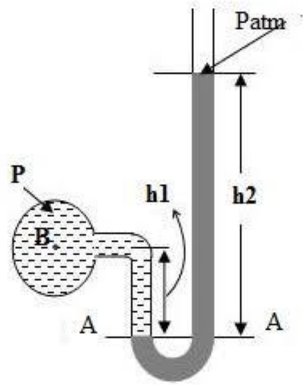
Let c be the center of pipe. Assume,

P = Pressure Intensity

S_1 = Specific Gravity of A;

S_2 = Specific Gravity of B.

$$\frac{P_C}{w} = Sh_2 - h_1$$



ART. 11. <u>Mechanical gauges</u>

For pressure higher than two atmosphere, mechanical gauges are used in which the liquid is counter balanced either by spring or dead weight.

<u>Advantages:</u>

1. Mechanical gauges are advantageous in the sense that they are portable.
2. Operation range is wider.
3. Direct reading is obtained. This is not the case with manometer.
4. Mechanical gauges are not fragile like manometer.

<u>Types of mechanical gauges.</u>

There are three types of mechanical gauges:

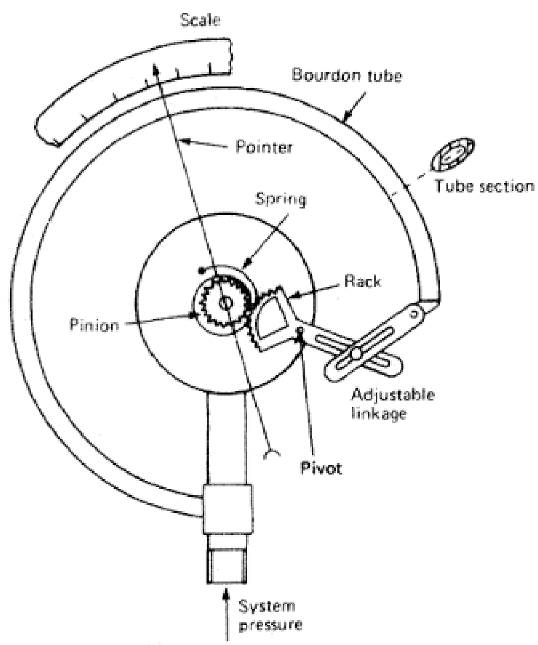
(i) Bourdon tube pressure gauge.
(ii) Diaphragm pressure gauge.
(iii) Dead weight pressure gauge.

ART. 12.<u>Bourdon tube pressure gauge</u>

Bourdon tube pressure gage is used to measure high as well as low pressures low pressure measurement tubes, generally, are made of bronze while for high pressure measurement nickel steel is generally used as tube material. (See figure).

Bourdon tube is a curved, elliptical-shaped, metallic tube. This tube is bent in the form of segment of a circle and responds to pressure changes when one end of the tube which is attached to gauge case, is connected to the pressure source, it tends to expand as the fluid pressure in tube rises. Hence circumferential stress is set up or we can say, hope tension is set up. As a result, free end of the tube moves. Free end is connected by suitable levers to Rack which, then, engages with a small pinion mounted on the same spindle as pointer.

Thus, Rack and pinion move. Pressure is indicated by the pointer over a printed dial.



Chapter-3 (FLOW OF FLUIDS)

ART .1. TYPES OF FLOW

[1] Steady Flow
[2] Un-Steady Flow
[3] Uniform Flow
[4] Non-Uniform Flow
[5] Compressible Flow
[6] Incompressible Flow
[7] Laminar Flow
[8] Turbulent Flow
[9] Rotational Flow
[10] Irrotational Flow

[1] Steady Flow

The flow in which fluid characteristics (fluid dependent variable) such as velocity, pressure, density at any given point in the fluid, do not change with time in the direction of any of the three coordinates is known as steady flow.

$$\frac{du}{dt} = \frac{dv}{dt} = \frac{dw}{dt} = 0; \quad \frac{d\rho}{dt} = 0; \frac{d\rho}{dt} = 0$$

[2] Unsteady Flow

When in flow, fluid characteristics such as velocity,temperature,density,pressure etc. changes with time at a given point, it is called unsteady flow.

$$\frac{du}{dt} \neq 0; \frac{dv}{dt} \neq 0; \frac{dz}{dt} \neq 0; \frac{dp}{dt} \neq 0;$$

[3] Uniform Flow

The flow in which fluid characteristics remain same throughout the flow field at a given time, is called uniform flow.

Mathematically,

$$\left(\frac{dv}{ds}\right)_{t=constant}$$

[4] Non-Uniform Flow

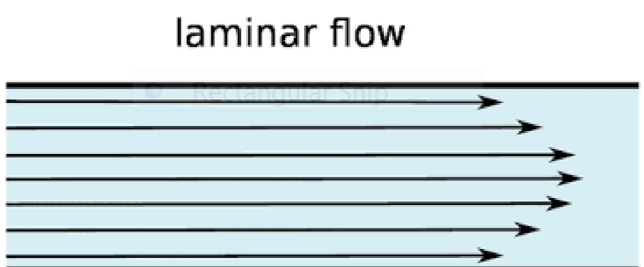
The flow in which the flow characteristics changes at various points along the path is called non-uniform flow.

Mathematically,

$$\left(\frac{dv}{ds}\right)_{t=constant} \neq 0$$

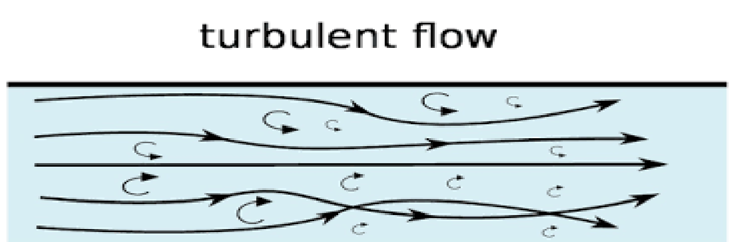
[5] Laminar Flow

Laminar flow is called as that type of flow in which the fluid elements move along well defined paths or stream lines and all the stream lines are straight and parallel.



[6] Turbulent Flow

The type of flow in which the fluid particles do not move in the layers and cross the path of other particles is called a turbulent flow.



ART. 2. CONTINUITY EQUATION OF FLOW

The equation which represents that the weight of liquid remains same at all sections provided no liquid is added or subtracted from the flowing liquid is referred as continuity equation of flow.

ART. 3. BERNOULLI'S THEOREM

Bernoulli's theorem is, actually, based on certain on certain assumptions these assumptions are:

1. No work or heat interaction between a fluid element and the surrounding takes place.
2. Flow is steady and continuous.
3. Fluid is incompressible and there is no friction.
4. The flow is one-dimensional i.e. it is along the stream line.

ART. 4. STATEMENT AND PROOF OF BERNOULLI'S THEOREM

"In a steady, continuous flow of an incompressible and ideal fluid, the sum of potential head, pressure head and kinetic head along a stream line flow remains same at all points".

Chapter-4 (flow through orifices)

INTRODUCTION

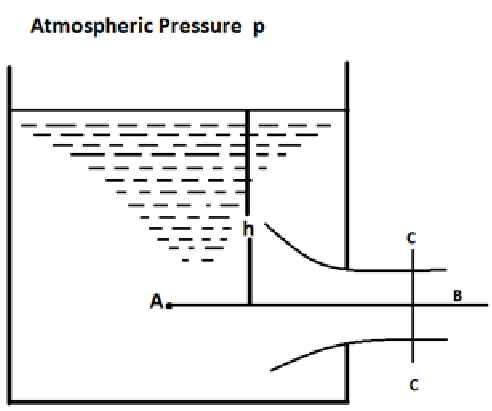
Flow of liquids through orifices is a very common phenomenon. Orifices actually is an opening or a hole of any size, shape or form through which liquid flows such that its upper edge remains below the free surface of liquid.

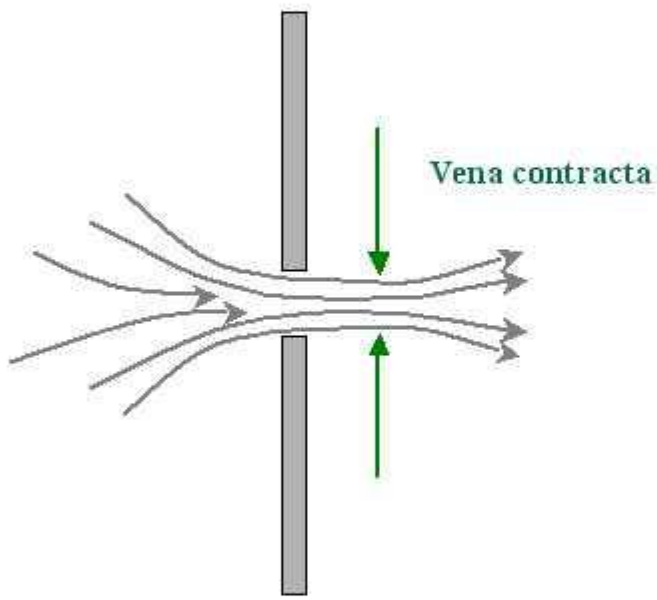
ART. 1.CLASSIFICATION OF ORIFICES

(1) Shape
(2) Size
(3) Discharge conditions
(4) Shape of upstream edge

ART. 2.VENA CONTRACTA

As a liquid approaches an opening, the liquid particles approaching it move along converging stream lines. This stream of particles issuing from the orifice is called jet this jet separates from the wall at the sharp edge and finally converges into a section of minimum cross-sectional area. This section of minimum cross-sectional area of a maximum contraction is called Vena contracta.





ART. 3. HYDRAULIC COEFFICIENTS

(a) coefficient of velocity: $\mathbf{C_V} = \dfrac{\textbf{Actual Velocity of Jet at Vena Contracta}}{\textbf{Theoretical Velocity}}$

(b) coefficient of contraction: $C_c = \dfrac{Area\ of\ Jet\ at\ Vena\ Contracta}{Area\ of\ Orifice}$

(c) coefficient of discharge:

$$\boldsymbol{C_d} = \frac{\boldsymbol{Actual\ Discharge}}{\boldsymbol{Theoretical\ Discharge}} = \frac{\boldsymbol{Actual\ Area \times Actual\ Velocity}}{\boldsymbol{Theoretical\ Area \times Theoritical\ velocity}} = \frac{\boldsymbol{Actual\ Area}}{\boldsymbol{Theoretical\ Area}} \times \frac{\boldsymbol{Actual\ Velocity}}{\boldsymbol{Theoretical\ Velocity}}$$

$$\boxed{C_d = C_C \times C_V}$$

Chapter-5 (FLOW THROUGH PIPES)

INTRODUCTION

A pipe may be defined as closed conduit carrying a fluid under pressure

ART. 1.GEOMETRICAL TERMINOLOGIES

[1] Depth of flow: depth of flow h is defined at a particular section of a channels. This is so because it may vary from section to section. Thus, depth of flow is the vertical distance of the bed of the channel from the free surface at the section under consideration.

[2] Top breadth: this is the breadth of channel section at the free surface.

[3] The water area, A: The water area is the flow cross-sectional area PERPENDICULAR TO THE direction of flow.

[4] Wetted perimeter:wetted perimeter is the perimeter of solid boundary in contact with the liquid. It is denoted by P.

ART. 2.LOSS OF ENERGY (OR HEAD) IN PIPE FLOW

ENERGY OR HEAD LOSSES pipe can be grouped; primarily, into following categories:

(1) Major energy loss.

(2) Minor energy loss.

(1) Major energy loss: this loss of energy is due to fraction in pipe can be calculated using following formulae

(i) Darcy-Weishbach formulae

(ii) Chezy's formulae

(2) Minor energy losses: minor energy losses are attributed to the following factors:

(i) Sudden expansion or contraction of pipe.

(ii) Bend in pipe.

(iii) Pipe fitting or an obstruction in pipe.

ART. 3.HYDRAULIC GRADIENT AND TOTAL ENERGY LINE

Total energy line (T.E.L.) means line or contour obtained on plotting total head at a section in flow direction while hydraulic gradient (H.G.L.) means line obtained on plotting pressure head (potential + pressure head of liquid at a section at against flow distance.

Chapter-6 (HYDRAULIC DEVICES)

INTRODUCTION

Devices which employ fluid or liquid in our case, as a medium for transmitting a force and power by high pressures are called hydraulic devices.

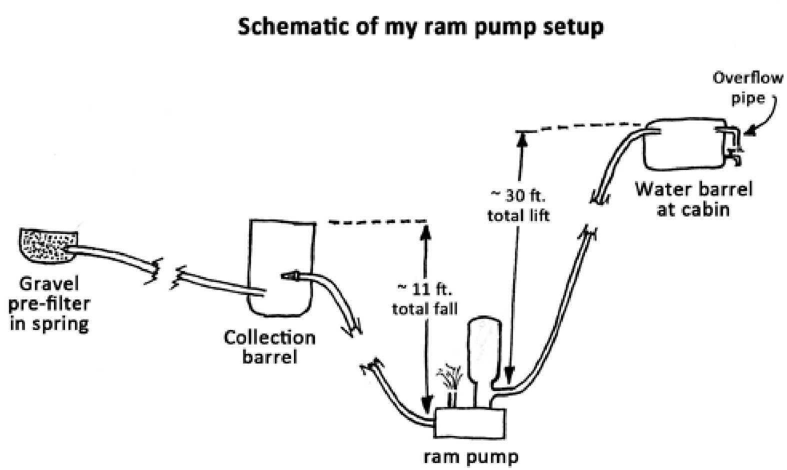
These are essentially based on the principle of fluid statics and fluid kinetics. Hydraulic devices which are being discussed in this chapter are:

1. Hydraulic ram
2. Hydraulic jack
3. Hydraulic accumulator
4. Hydraulic press
5. Hydraulic lift

ART. 1. HYDRAULIC RAM

Hydraulic ram is a device which can lift a small quantity of water to a greater height when a large quantity of water is available at a smaller height without using any external power, be it mechanical or electrical.

Principle: It utilizes the water hammer principle to raise the pressure energy of small quantity of water and can also be called an "impulse pump".



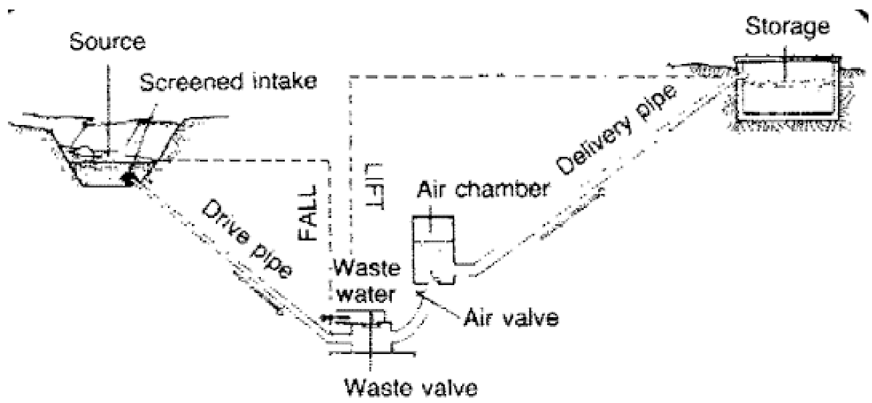
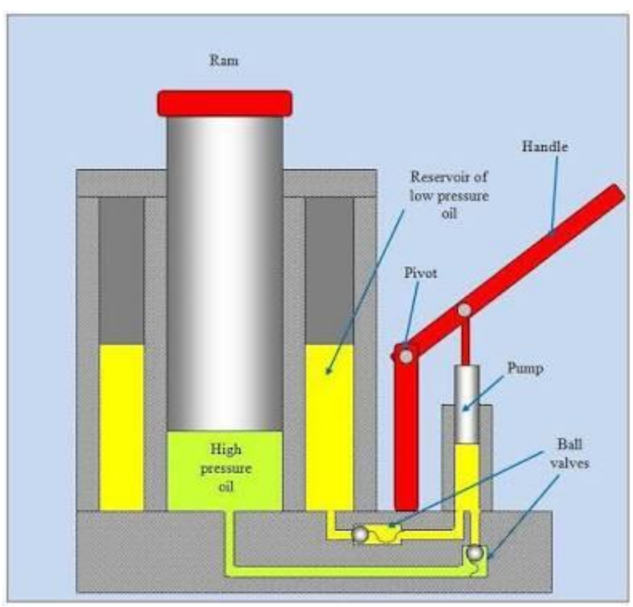


Figure 1. Hydraulic Ram Pump

ART. 2.<u>THYDRAULIC JACK</u>

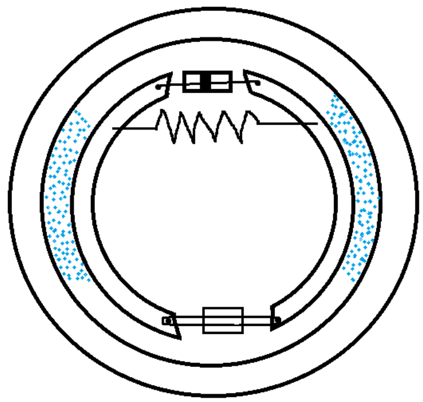
Hydraulic JACK IS A DEVICE USED TO LIFT HEAVY LOADS. Principle of this device is Pascal's law of transmission of pressure by fluid combined with the operation of force pump.

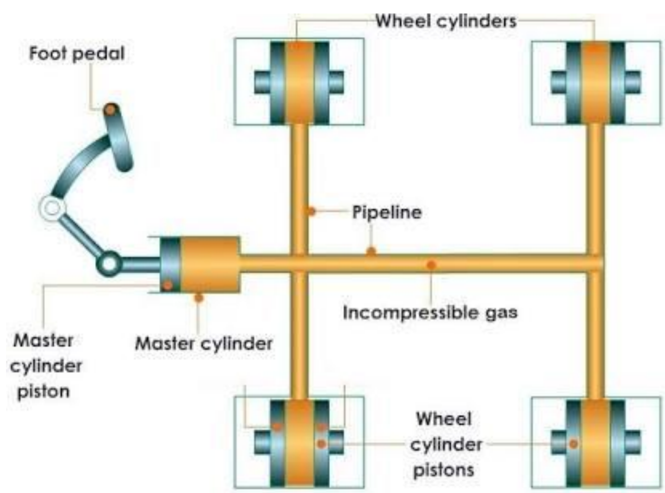
Fig. shows the cross-section of simple hydraulic jack. It consists of a ram which can raise the load as desired, a pump; a reservoir and small cylinder containing plunger. Initially, as the handle is raised, plunger moves up in its cylinder. At this moment, oil from the reservoir flows out of hole and underside of plunger. Thereafter, plunger is pushed down closing the hole through which oil entered into small cylinder, then pushing the oil through a check valve into the large cylinder. Oil builds up pressure in large cylinder gradually with each stroke of the pump rising in the piston and load placed on it.



ART. 3. **<u>Hydraulic BREAK</u>**

ACCORDING TO METHOD OF actuation brakes are classified as hydraulic brake, magnetic brake or eddy-current brakes. A hydraulic braking system has been shown in fig. primarily, a hydraulic breaking system is a liquid coupling between brake pedal and individual brake shoe.





WORKING OF PNEUMATIC BRAKE SYSTEM

Chapter-7 (WATER TURBINES AND PUMPS)

ART. 1. **CLASSIFICATION OF TURBINES**

Broadly, turbines are classified on following two basis:

(i) Hydraulic action of water or nature of energy head processed by water at inlet.

(ii) Direction of flow of water in the runner or we can say direction of flow along the vanes

ART. 2.1 **HYDRAULIC ACTION OF WATER OR NATURE OF ENERGY HEAD**

On this basis, turbines are classified as under:

(1) Impulse turbines

(2) Reaction turbines

[1] Impulse Turbines

Those turbine in which runner rotates by impulse action (impact) of water are called impulse turbines.

Examples of impulse turbines are: Pelton Wheel, Girard Turbine.

[2] Reaction Turbines

Those turbines in which the water entering the runner possesses pressure as well as kinetic energy are called reaction turbines.

Examples: Francis Turbine, Kaplan Turbine.

ART. 2.2 **CLASSIFICATION ACCORDING TO DIRECTION OF FLOW OF WATER IN RUNNER**

ON THE BASIS OF DIRECTION OF FLOW OF WATER, turbines are classified as under:

(1) Tangential Flow Turbines

(2) Radial Flow Turbines

ART. 3. **Comparison between Impulse and Reaction Turbines**

S. No.	Impulse Turbine	Reaction Turbine
1.	The total available head is converted into velocity head by using a nozzle.	Only a part of available head is converted into velocity head rest of it being converted into pressure head. No separate nozzle is used.
2.	Only the jet velocity changes in the process of fluid flow.	Both pressure and velocity changes as fluid flow through the runner.
3.	Water is admitted over part of circumstance.	Water must be admitted over the entire circumference of the runner.
4.	Water tight casing is not required as the casing has no hydraulic function to perform as such. It simply prevents splashing of water and finally leads the water to tail race.	Water tight casing is must for enclosing the runner.
5.	Turbine is always installed above tail race.	It may be installed both above and below tail race.
6.	No draft tube is used.	Draft tube is used.
7.	Air has free access to vanes as the wheel does not run full.	Air runner wheel always run full.