Types of fluid:

i. Ideal Fluid: A fluid, which is incompressible and is having no viscosity, is known as an ideal fluid. Ideal fluid is only an imaginary fluid as all the fluids, which exist, have some viscosity.

ii. Real Fluid: A fluid, which possesses viscosity, is known as real fluid. All the fluids are real fluids in actual practice.

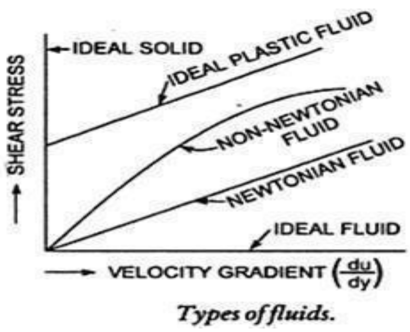


Fig.4. Types of Fluid

iii. Newtonian Fluid: A real fluid, in which the shear stress is directly proportional to the rate of shear strain (or) velocity gradient, is known as a Newtonian fluid.

iv. Non-Newtonian Fluid: A real fluid, in which the shear stress is not proportional to the rate of shear strain (or) velocity gradient, is known as a Non-Newtonian fluid.

v. Ideal Plastic Fluid: A fluid, in which shear stress is more than the yield value and shear stress is proportional to the rate of shear strain (or) velocity gradient, is known as ideal plastic fluid

Fluid Pressure

Fluid pressure is the force exerted by the fluid per unit area.

Fluid pressure or Intensity of pressure or pressure, = Fluids exert pressure on surfaces with which they are in contact.

Fluid pressure is transmitted with equal intensity in all directions and acts normal to any plane.
In the same horizontal plane the pressure intensities in a liquid are equal.

S.I unit of fluid pressure are N/m² or Pa, where 1 N/m² = 1 Pa.

Many other pressure units are commonly used:
1 bar = 10^5 N/m²
1 atmosphere = 101325 N/m² = 101.325kN/m²

Some Terms commonly used in static pressure analysis include:

Pressure Head***: The pressure intensity exerted at the base of a column of homogenous fluid of a given height in metres.***

Vacuum: A perfect vacuum is a completely empty space in which, therefore the pressure is zero.

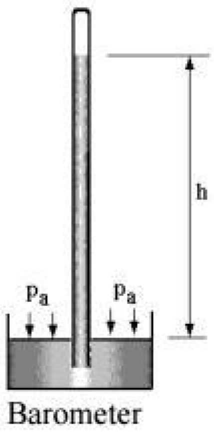
Atmospheric Pressure ***:*** The pressure at the surface of the earth exerted by the head of air above the surface.

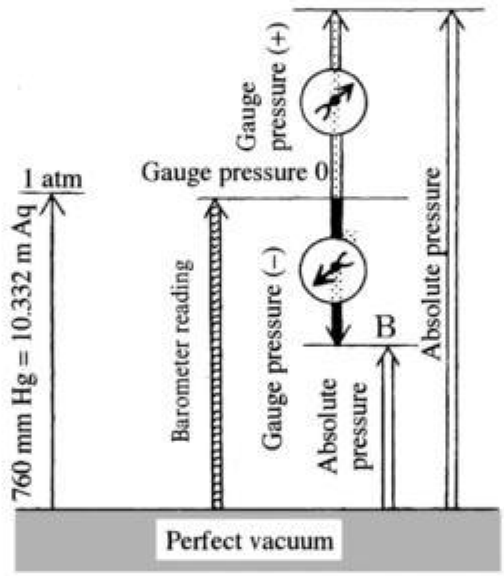
At sea level the atmospheric pressure = 101.325 kN/m² = 101325 N/m² or pa
= 1.01325 bar
= 760 mm of mercury
= 10.336 m of water

Atmospheric pressure is measured by a device called a barometer; thus, the atmospheric pressure is often referred to as the barometric pressure.

Gauge Pressure: The pressure measured by a pressure gauge above or below atmospheric pressure.
Vacuum pressure: The gauge pressure less than atmospheric is called Vacuum pressure or negative pressure.
Absolute Pressure: The pressure measured above absolute zero or vacuum.

Absolute Pressure = Atmospheric Pressure + Gauge Pressure
Absolute Pressure = Atmospheric Pressure – Vacuum pressure





Atmospheric, Gauge & Absolute pressure

Fig.5. Barometer, Atmospheric, Gauge and Absolute Pressure

Hydrostatic law

The **hydrostatic law** is a principle that identifies the amount of pressure exerted at a specific point in a given area of fluid.

It states that, "The rate of increase of pressure in the vertically downward direction, at a point in a static fluid, must be equal to the specific weight of the fluid."

Pressure Variation in static fluid

Consider a small vertical cylinder of static fluid in equilibrium.

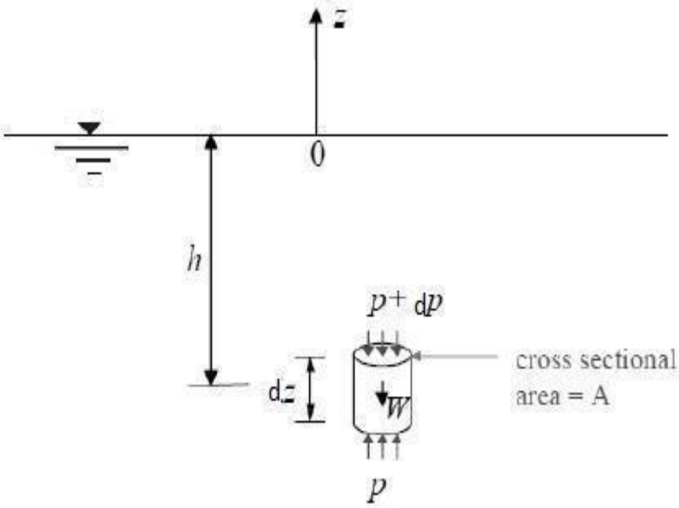


Fig.6. Pressure variation in static fluid

Assume that the sectional area is "**A**" and the pressure acting upward on the bottom surface is **p** and the pressure acting downward on the upper surface (dz above bottom surface) is (p + dp)dz.

Let the free surface of the fluid be the origin, i.e., $Z = 0$. Then the pressure variation at a depth $Z = -h$ below the free surface is governed by

$(p + dp) A + W = pA$

⇨ $dpA + \rho gAdz = 0$ [$W= w$ x volume $= \rho g Adz$] $dp = -\rho gdz$

⇨

$\underline{=} - \rho g = - w$

Therefore, the hydrostatic pressure increases linearly with depth at the rate of the specific weight, $w = \rho g$ of the fluid.

If fluid is homogeneous, ρ is constant.

By simply integrating the above equation,

$\int dp = - \int \rho g \, dz \quad => \quad p = - \rho g Z + C$

Where C is constant of integration.

When $z = 0$ (on the free surface), $p = C = p_o$ = the atmospheric pressure.

Hence, $p = - \rho gZ + p_o$

Pressure given by this equation is called ABSOLUTE PRESSURE, i.e., measured above perfect vacuum.

However, it is more convenient to measure the pressure as gauge pressure by setting atmospheric pressure as datum pressure. By setting $p_o = 0$,

$p = -\rho gz+0 = -\rho gz = \rho gh$

p = *w*h

The equation derived above shows that when the density is constant, the pressure in a liquid at rest increases linearly with depth from the free surface.

Here, **h** is known as ***pressure head*** or simply ***head*** of fluid.

In fluid mechanics, fluid pressure is usually expressed in height of fluids or head of fluids.

Hydrostatic force

Hydrostatic pressure is the force exerted by a static fluid on a plane surface, when the static fluid comes in contact with the surface. This force will act normal to the surface. It is also known as ***Total Pressure***.

The point of application of the hydrostatic or total pressure on the surface is known as ***Centre of pressure***.

The vertical distance between the free surface of fluid and the centre of pressure is called depth of centre of pressure or location of hydrostatic force.

Total Pressure on a Horizontally Immersed Surface

Consider a plane horizontal surface immersed in a liquid as shown in figure.

Let, w = Specific weight of the liquid, kN/m^3

A = Area of the immersed surface in m^2

= Depth of the horizontal surface from the liquid level in

m We know that,

Total pressure on the surface, **P** = Weight of the liquid above the immersed surface