Density: $\rho = \dfrac{Mass}{Volume}$

Example: density of water $\mathbf{1000\frac{kg}{m^3} = 1\frac{kg}{l} = 1\frac{g}{cm^3} = 1\frac{g}{ml}}$

Pressure = $\dfrac{\text{Force}}{\text{Area}}$

Units of Pressure:

$1Pa = 1\frac{N}{m^3}$ (standard SI unit called Pascal)

$1\ bar\ = 100\ kPa = 10^5 Pa$

Atmospheric Pressure $1\ atm = 101\ kPa,$ it is very close to 1 bar.

Pressure in fluids

- **Pascal's Principle:**

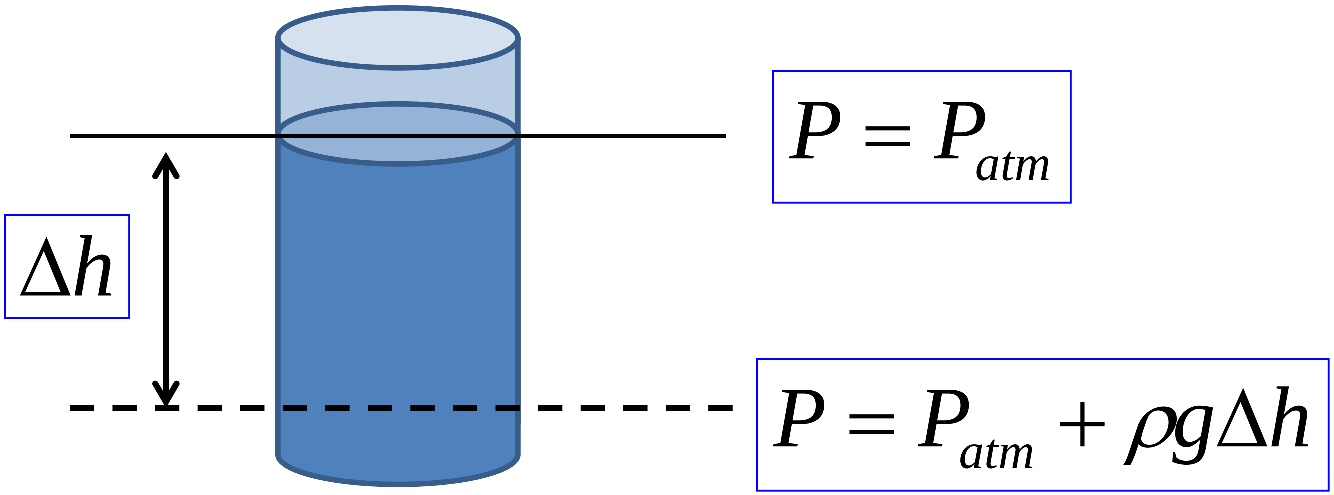
"Pressure in static fluid is transmitted uniformly in all directions"

P = *const*

(static fluid, no gravity)

- **Hydrostatic Pressure.** Due to gravity, the pressure increases as you go deeper in fluid:

$$\Delta P = \rho g \Delta h$$



Temperature

- Temperature T determines the direction of heat transfer. Heat between two objects in contact flows from the hotter one to colder one. Eventually, their temperatures will equilibrate: $T_1 = T_2$.
- The most common is Celsius temperature scale. T= 0°C is the melting point of ice, and T= 100°C is the boiling temperature of water at atmospheric pressure.
- Many properties of matter depend on temperature. For most substances, volume increases upon heating (exception: water near freezing point, between 0°C and 4°C).
- Thermal Expansion Coefficient (units 1/°C):

$$a = \frac{1}{V}\frac{\Delta V}{\Delta T}$$

- Example: a = $1.8 \cdot 10^{-4}$ 1/°C for Mercury (Hg). This means that as temperature increases by ΔT= 10°C, a mercury droplet of initial volume V will grow by the amount $\Delta V = aV\,\Delta T = 1.8 \cdot 10^{-3}\,V$, or by 0.18%.
- Another way to characterize thermal expansion is to use Linear Thermal Expansion coefficient, a_L. It tells how much linear dimensions (say, length) changes with temperature:

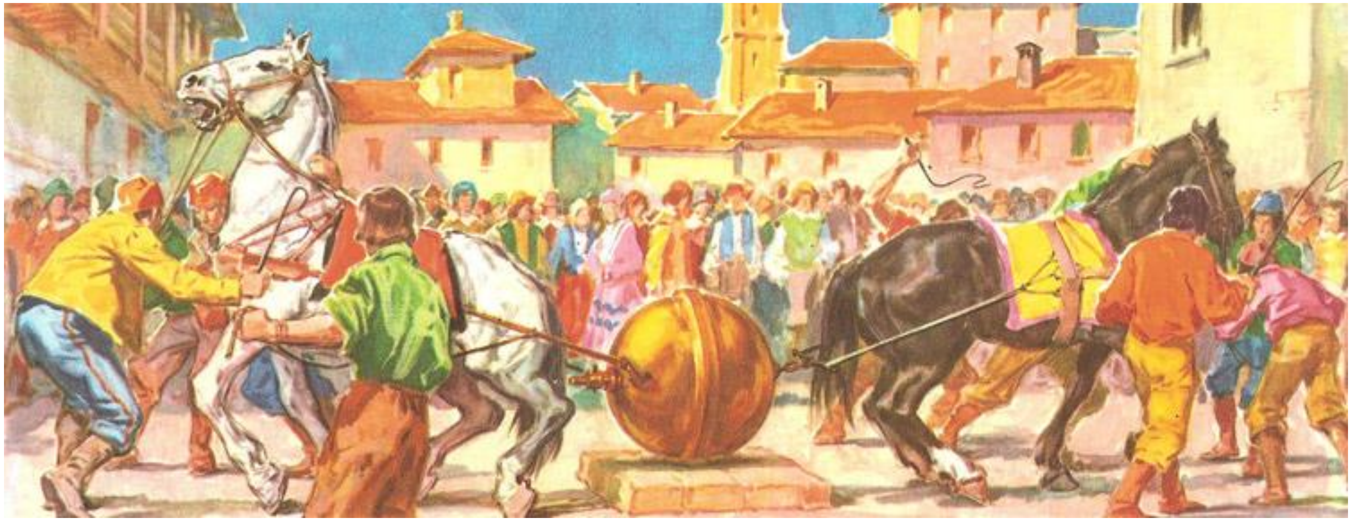
$$a_L = \frac{1}{L}\frac{\Delta L}{\Delta T}$$

- For all liquids and many solids, $a_L = a/3$.

Homework

Problem 1

The figure shows the famous experiment conducted in German city of Magdeburg in 1656. Air has been pumped out of a hollow sphere made of two separate halves. After that, the hemispheres could not be separated by two strong horses. **Why?**



How much force would be needed to separate them, if the sphere radius is 25 cm?

Problem 2

How much taller is the Eiffel Tower on the hot summer day (30 °C) than on cold winter day (-5°C)? The tower is 324 m tall measured from the top of the flagpole. Assume the tower is built of structural steel. (It's actually made of "puddle iron".)