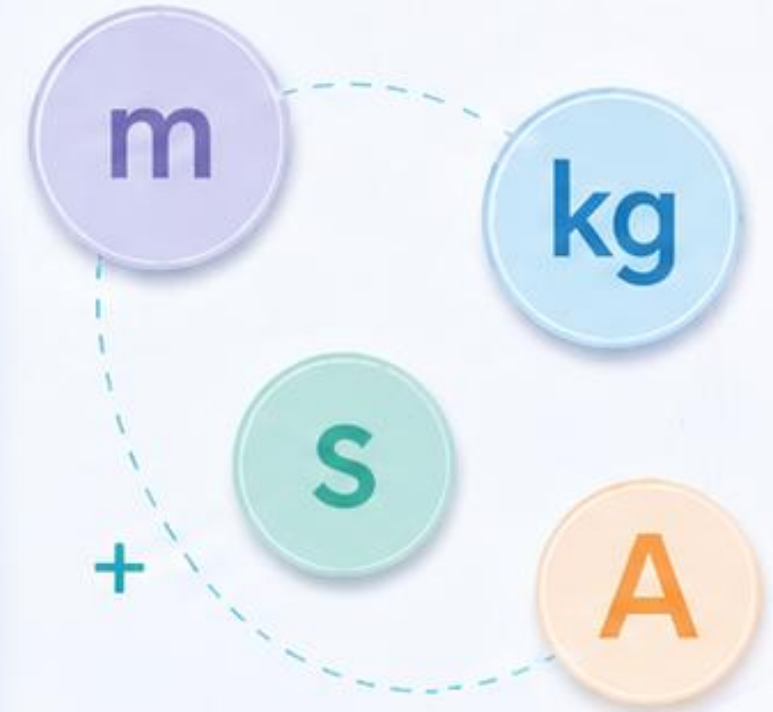
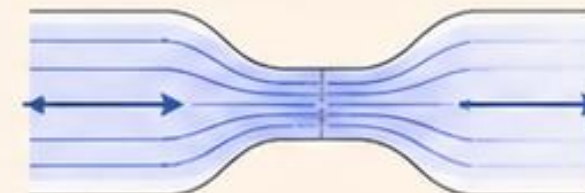


Chapter 9

Mechanical Properties of Fluids

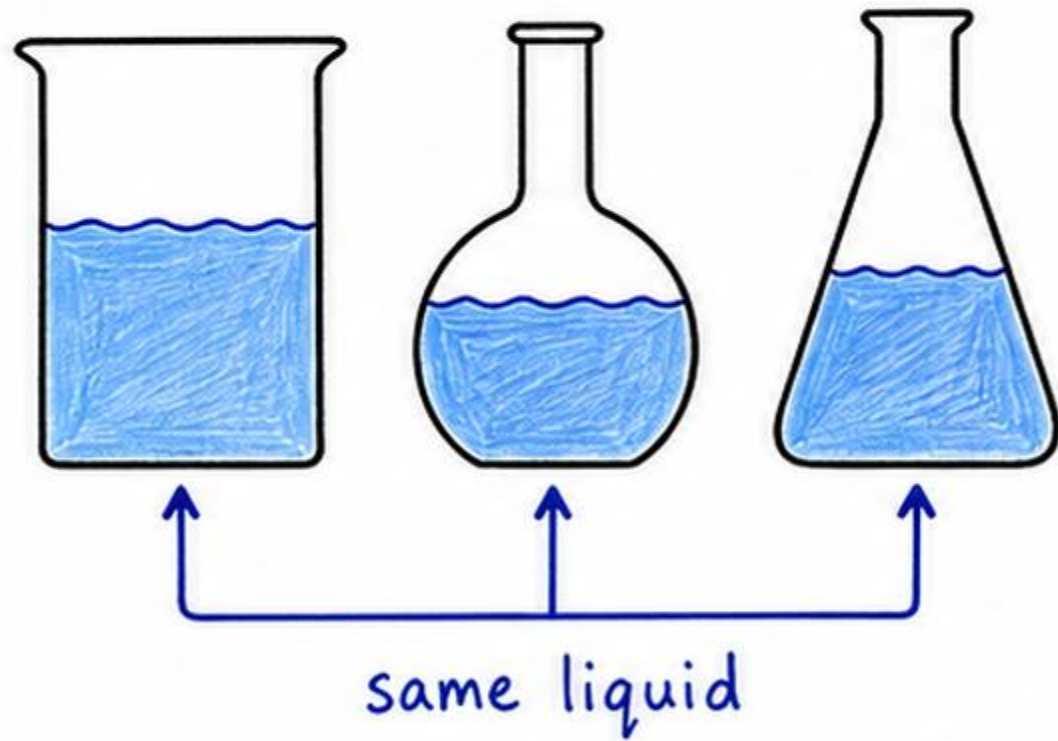
Pressure • Buoyancy • Viscosity



FLUIDS: FLOW, SHAPE & VOLUME

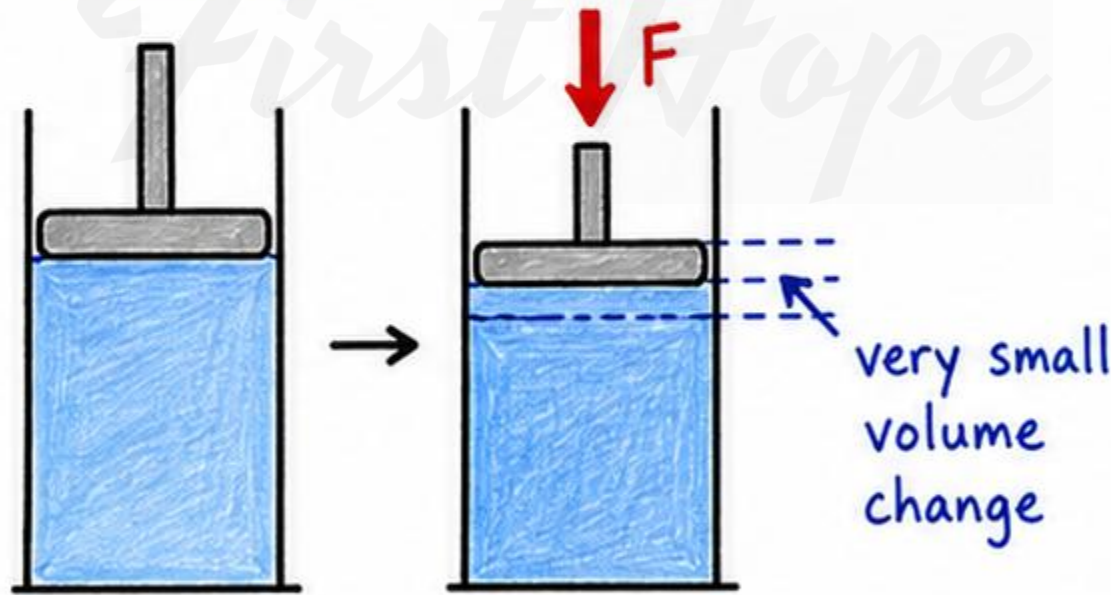
WHAT IS A FLUID?

- A fluid is a substance that can flow.
- Liquids and gases are fluids.
- A fluid has no fixed shape; it takes the shape of its container.



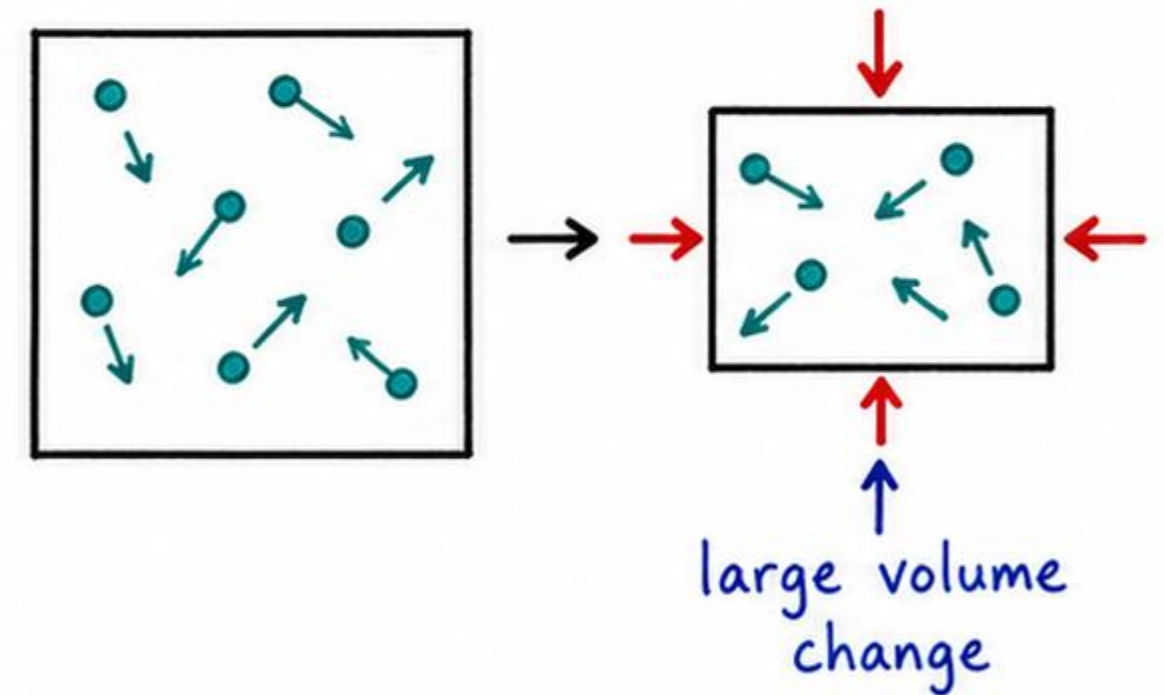
LIQUIDS

- Liquids have a definite volume.
- They are nearly incompressible: pressure produces only a very small change in volume.
- A liquid has a free surface when open to air.



GASES

- Gases have neither fixed shape nor fixed volume.
- They expand to fill the complete container.
- Gases are much more compressible than liquids.



WHY FLUID MECHANICS?

Fluid mechanics studies fluids at rest and in motion. It helps us understand pressure, flow, lift, viscosity and surface tension.

FLUID PRESSURE & DENSITY

PRESSURE

- Pressure is the normal force acting per unit area.

$$P = \frac{F_{\perp}}{A}$$

Define clearly:

P = pressure

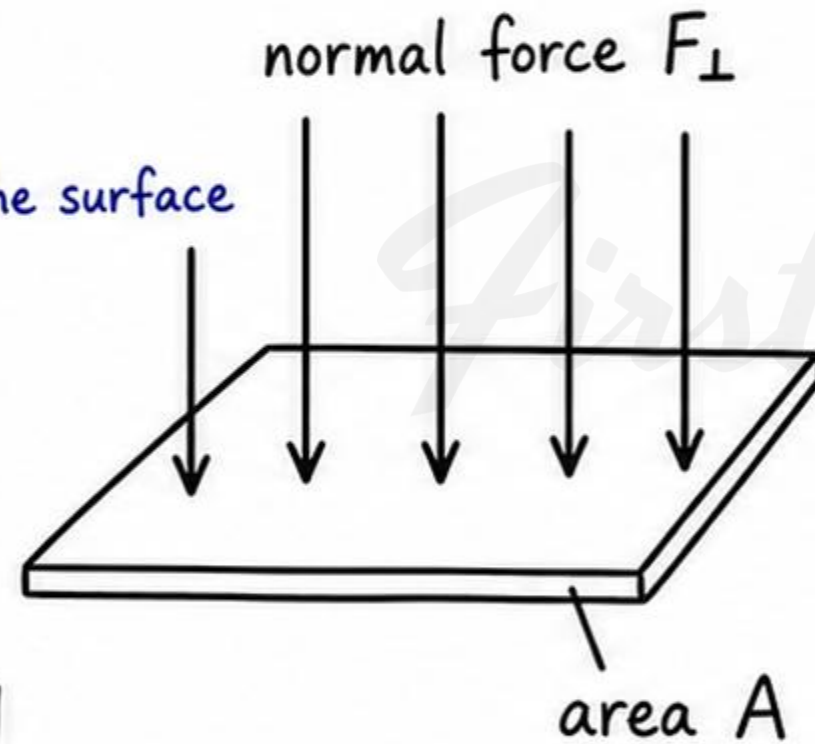
$F_{\perp}$ = force perpendicular (normal) to the surface

A = area of the surface

SI unit: pascal (Pa)

$$1 \text{ Pa} = 1 \text{ N m}^{-2}$$

$$\text{Dimensions: } [P] = [M L^{-1} T^{-2}]$$



DENSITY

- Density is mass per unit volume.

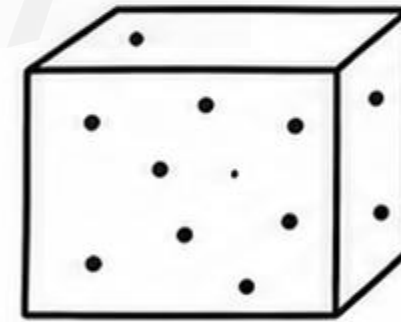
$$\rho = \frac{m}{V}$$

Define:

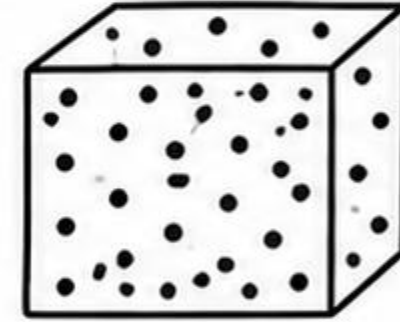
ρ = density, m = mass, V = volume

SI unit: kg m^{-3}

$$\text{Dimensions: } [\rho] = [M L^{-3}]$$



lower density



higher density

RELATIVE DENSITY

Relative density = density of substance / density of water at 4°C

$$\text{relative density} = \frac{\rho_{\text{substance}}}{\rho_{\text{water}}}$$

- It has no unit because it is a ratio of two densities.

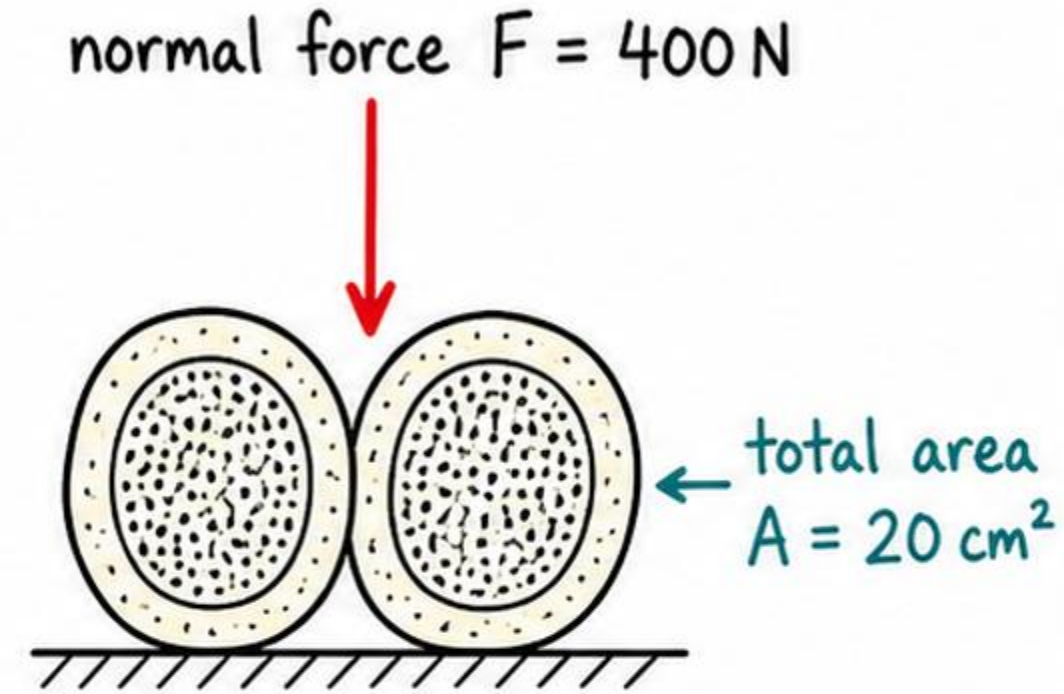
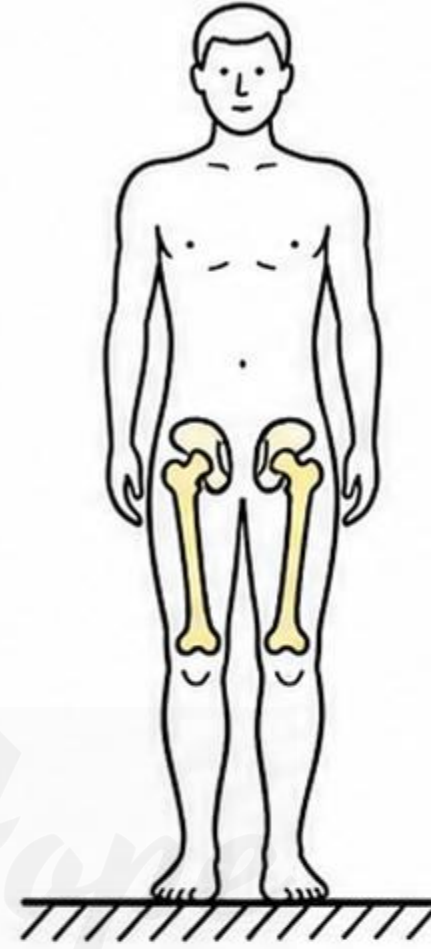
$$\text{If } \rho_{\text{oil}} = 800 \text{ kg m}^{-3},$$

$$\text{relative density} = \frac{800}{1000} = 0.8$$

WORKED EXAMPLE 9.1: PRESSURE ON FEMURS

QUESTION

A person weighing 400 N stands on two femurs. Their total cross-sectional area is 20 cm². Find the average pressure supported by the femurs.



SOLUTION

1. Formula:

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

2. Convert area:

$$20 \text{ cm}^2 = 20 \times 10^{-4} \text{ m}^2 = 2.0 \times 10^{-3} \text{ m}^2$$

3. Substitute:

$$P = \frac{400 \text{ N}}{(2.0 \times 10^{-3} \text{ m}^2)}$$

4. Calculate:

$$P = 2.0 \times 10^5 \text{ N m}^{-2}$$

5.

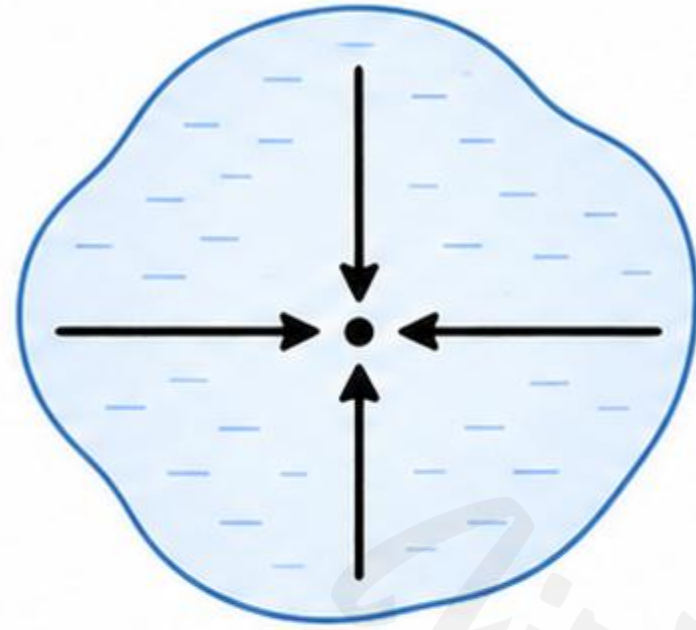
$$P = 2.0 \times 10^5 \text{ Pa}$$

The pressure is an average value because the force is distributed over the total area of both femurs.

PASCAL'S LAW IN A FLUID AT REST

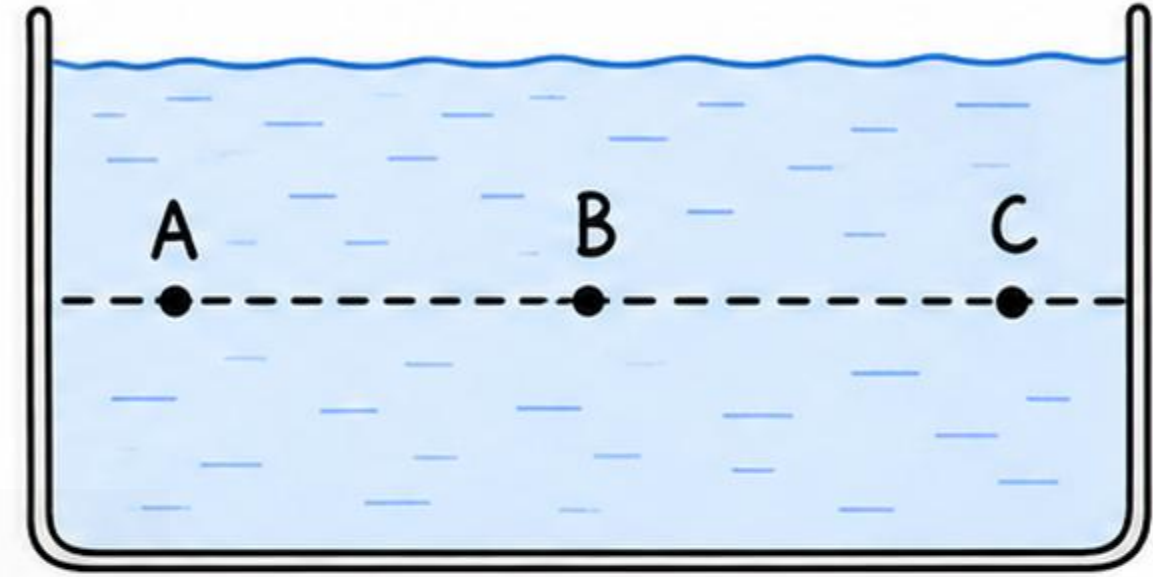
PRESSURE AT A POINT

- ① A fluid at rest cannot support a tangential (shearing) force.
- ② Pressure force on any small surface is normal to that surface.
- ③ At one point in a fluid at rest, pressure has the same value in every direction.



$$P = \frac{F_{\perp}}{A}$$

SAME HORIZONTAL LEVEL

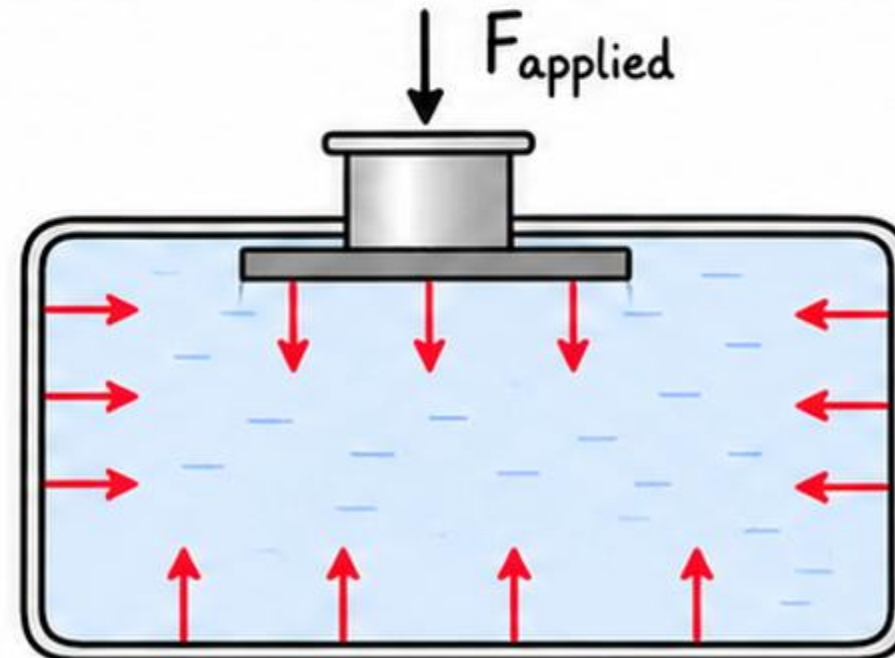


$$P_A = P_B = P_C$$

Points in the same connected fluid, at rest and at the same height, have equal pressure.

PASCAL'S LAW

When pressure is applied to an enclosed fluid, the pressure change is transmitted equally and undiminished to every part of the fluid and to the walls of the container.



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hydraulic brakes

hydraulic press



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