Al-Mustaqbal University

College of Engineering & Technology

Biomedical Engineering Department

Subject Name: Physics

1st Class, First Semester

Subject Code: [Insert Subject Code Here]

Academic Year: 2024-2025

Lecturer: Assist lect. Hiba Diaa Alrubaie

Email: hiba.diaa.abdulameer@uomus.edu.iq

Lecture No.:-4

Lecture Title: [Fluids in Statics]

1. What is a fluid?

Fluids are substances that have the ability to flow.

- They do not have a fixed shape.
- Their molecules are arranged randomly and are held together by weak intermolecular cohesive forces, as well as by the walls of their container.
- Both **liquids** and **gases** are classified as fluids.

Liquids have a definite volume but lack a fixed shape.

- They are generally almost incompressible when subjected to pressure from all directions.
- Liquids cannot resist tension or shear stress (force applied sideways).
- While they lack long-range molecular order, nearby molecules may weakly interact with one another.

Gases have neither a fixed volume nor a defined shape.

- Their molecules move freely and independently.
- Gases are relatively easy to compress, and their density varies depending on temperature and pressure.

Mass and Density

- Density is mass per unit volume at a point :

$$\rho \equiv \frac{\Delta m}{\Delta V} \quad \text{or} \quad \rho \equiv \frac{m}{V}$$

- scalar
- units are kg/m3, gm/cm3..
- water= 1000 kg/m3= 1.0 gm/cm3

- Volume and density vary with temperature - slightly in liquids
- The average molecular spacing in gases is much greater than in liquids.

Densities of Some Common Substances at Standard Temperature (0°C) and Pressure (Atmospheric)

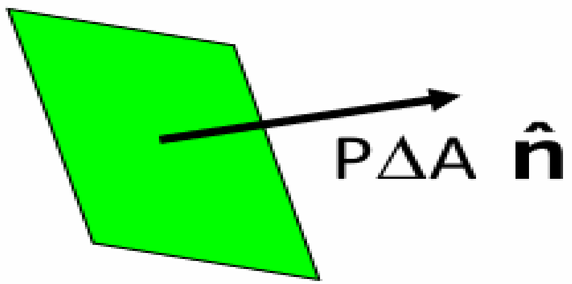
Substance	ρ (kg/m^3)	Substance	ρ (kg/m^3)
Air	1.29	Ice	0.917×10^3
Aluminum	2.70×10^3	Iron	7.86×10^3
Benzene	0.879×10^3	Lead	11.3×10^3
Copper	8.92×10^3	Mercury	13.6×10^3
Ethyl alcohol	0.806×10^3	Oak	0.710×10^3
Fresh water	1.00×10^3	Oxygen gas	1.43
Glycerin	1.26×10^3	Pine	0.373×10^3
Gold	19.3×10^3	Platinum	21.4×10^3
Helium gas	1.79×10^{-1}	Seawater	1.03×10^3
Hydrogen gas	8.99×10^{-2}	Silver	10.5×10^3

Force & Pressure

- The pressure P on a “small” area ΔA is the ratio of the magnitude of the net force to the area

$$P = \frac{\Delta F}{\Delta A} \quad \text{or} \quad P = F/A$$

$$\Delta\vec{F} = P\Delta\vec{A} = P\Delta A\hat{n}$$

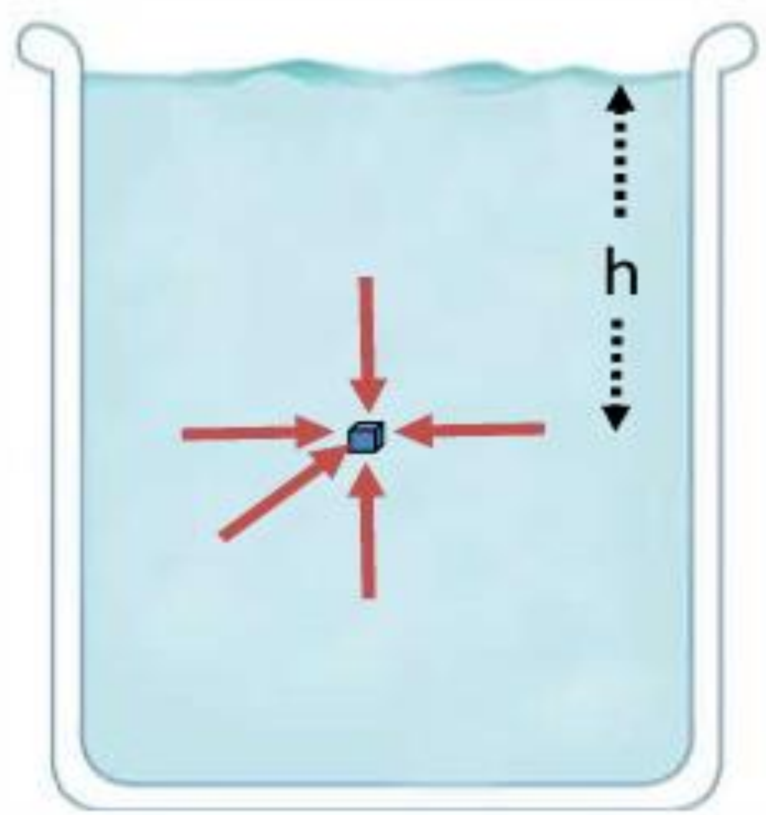


- Pressure is a scalar while force is a vector
- The direction of the force producing a pressure is perpendicular to some area of interest

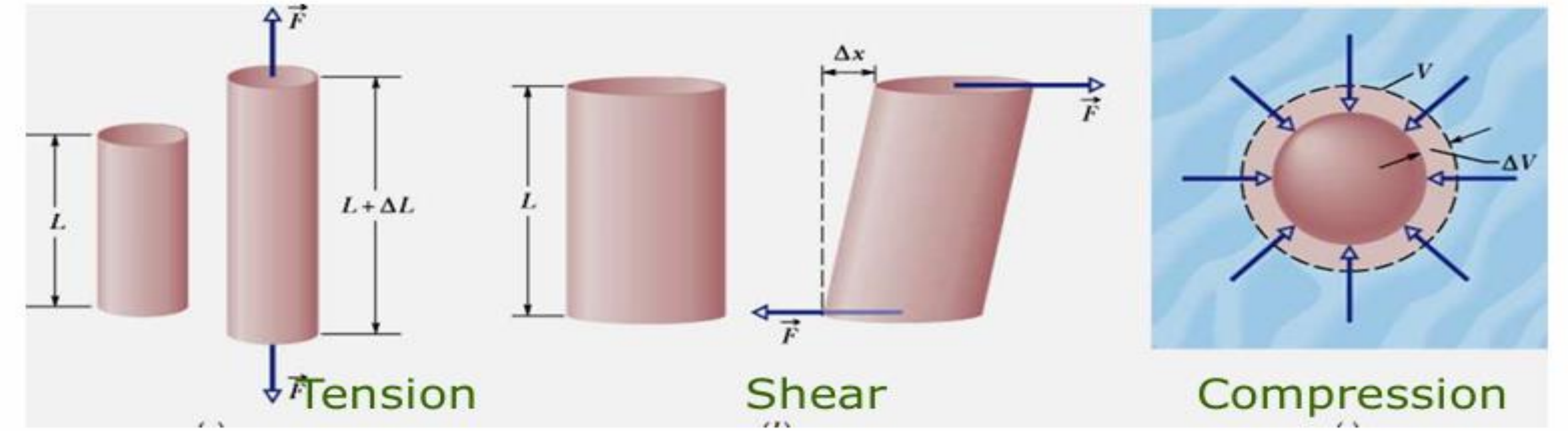
- At a point in a fluid (in mechanical equilibrium)
- the pressure is the same in any direction

Pressure units:

- 1 Pascal (Pa) = 1 Newton/m2 (SI)
- 1 PSI (Pound/sq. in) = 6894 Pa.
- 1 milli-bar = 100 Pa.



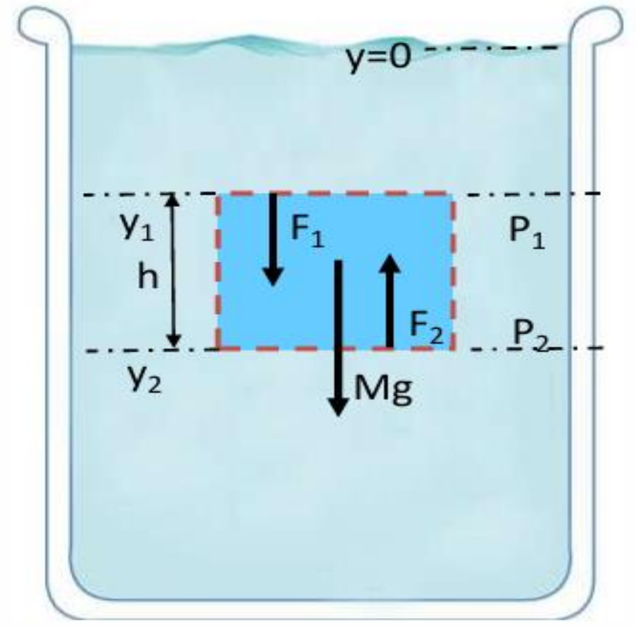
Forces/Stresses in Fluids



- The only stress that can be exerted on an object submerged in a static fluid is one that tends to compress the object from all sides
- The force exerted by a static fluid on an object is always perpendicular to the surfaces of the object

Pressure in a fluid varies with depth

- Fluid is in static equilibrium The net force on the shaded volume = 0
- Incompressible liquid - constant density
- Horizontal surface areas = A
- Forces on the shaded region:–
- Weight of shaded fluid: Mg
- Downward force on top: F1 =P1A
- Upward force on bottom: F2 = P2A



$$\sum F_y = 0 = P_2A - P_1A - Mg$$

- In terms of density, the mass of the shaded fluid is:

$$M = \rho\Delta V = \rho Ah$$

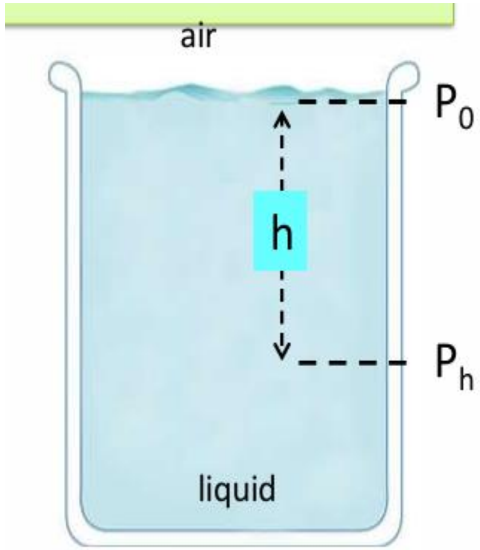
$$\therefore P_2A = P_1A + \rho ghA$$

The extra pressure at extra depth h is:

$$\Delta P = P_2 - P_1 = \rho gh$$

$$h \equiv y_1 - y_2$$

Pressure relative to the surface of a liquid refers to the pressure exerted by the liquid at a given depth, measured relative to the liquid's surface. This pressure is influenced by the liquid's density, gravitational acceleration, and the depth of the point of interest.



The pressure at a given depth in a fluid can be calculated using the formula:

$$P = P_0 + \rho g h$$

Where:

- P is the pressure at the given depth,
- P0 is the atmospheric pressure at the surface of the liquid (or the pressure at the surface, if no atmospheric pressure is considered),
- ρ is the density of the liquid,
- g is the acceleration due to gravity,
- h is the depth below the surface of the liquid.

This formula shows that as the depth increases, the pressure also increases due to the weight of the liquid above the point of interest.

Measurement of Pressure

There are many ways to measure pressure in a fluid. Some are discussed here:

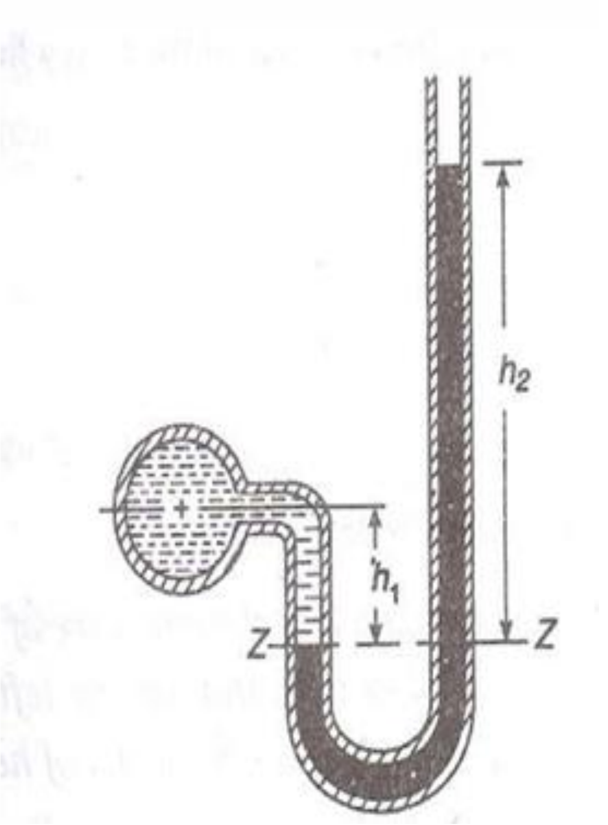
1. Barometers
2. Bourdon gauge
3. Pressure transducers
4. Piezometer Column
5. Simple Manometers
6. Differential Manometers

Manometer:

Manometer is an improved form of a piezometer tube. With its help we can measure comparatively high pressures and negative pressure also. Following are few

types of manometers.

1. Simple Manometer
2. Micro-manometer
3. Differential manometer
4. Inverted differential manometer



Consider a simple Manometer connected to a pipe containing a light liquid under high pressure. The high pressure in the pipe will force the mercury in the left limb of U-tube to move downward, corresponding the rise of mercury in the right limb.