Introduction to Fluid Mechanics

Background

Several scientists have contributed to the science of fluid mechanics

- **Archimedes (250 B.C) :** Principles of hydrostatic and flotation
- **Newton:** Momentum equation.
- **Reynold:** Laminar & Turbulence.
- **Prandtl:** Boundary layer.
- **Euler & Bernoulli:** Fluid motion.
- **Mach:** Supersonic flow.
- **Riemann:** Shock waves.

Definitions

Fluid Mechanics

- The science that deals with the action of forces on fluid.
- Physical science dealing with the action of fluids at rest (Fluid Statics) or in motion (fluid dynamics), and their interaction with flow devices and applications in engineering.
- The branch of mechanics that deal with gases and liquids, either at rest or in motion.
- The study in which the fundamentals principles of general mechanics are applied to liquids and gases. These principles are the conservation of matter (mass), conservation of energy and Newton laws of motion.

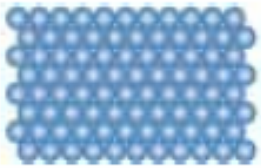
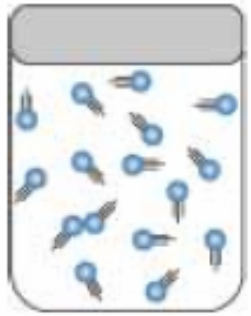
Definitions

Fluid (Liquid, Gas & Plastic solids)

- Fluid is defined as a substance that continually deforms (flows) under an applied shear stress regardless of how small the applied stress.
- Continuous, amorphous substance whose molecules move freely past one another and that has the tendency to assume the shape of its container; a liquid or gas.
- Any state of matter which can flow with relative ease, tends to assume the shape of its container, and obeys Bernoulli's principle; a liquid, gas.
- Anything that flows, either liquid or gas. Some solids can also exhibit fluid behavior over time.

Solids, Liquid & Gases

Table 1.1 COMPARISON OF SOLIDS, LIQUIDS, AND GASES

Attribute	Solid	Liquid	Gas
Typical Visualization			
Macroscopic Description	Solids hold their shape; no need for a container	Liquids take the shape of the container and will stay in open container	Gases expand to fill a closed container
Mobility of Molecules	Molecules have low mobility because they are bound in a structure by strong intermolecular forces	Liquids typically flow easily even though there are strong intermolecular forces between molecules	Molecules move around freely with little interaction except during collisions; this is why gases expand to fill their container

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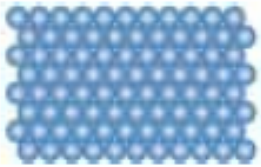
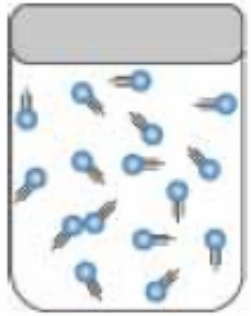
Typical Visualization			
Typical Density	Often high; e.g., density of steel is 7700 kg/m^3	Medium; e.g., density of water is 1000 kg/m^3	Small; e.g., density of air at sea level is 1.2 kg/m^3
Molecular Spacing	Small—molecules are close together	Small—molecules are held close together by intermolecular forces	Large—on average, molecules are far apart
Effect of Shear Stress	Produces deformation	Produces flow	Produces flow
Effect of Normal Stress	Produces deformation that may associate with volume change; can cause failure	Produces deformation associated with volume change	Produces deformation associated with volume change
Viscosity	NA	High; decreases as temperature increases	Low; increases as temperature increases
Compressibility	Difficult to compress; bulk modulus of steel is 160×10^9 Pa	Difficult to compress; bulk modulus of liquid water is 2.2×10^9 Pa	Easy to compress; bulk modulus of a gas at room conditions is about

Flow Classification

1. Hydrodynamics.

The study of fluid in motion when there is **no change in density** **OR** the **flow of gas at low speeds.**
(Examples: Flow in a pipe or open channel, rivers and immersed bodies).

2. Gas dynamics.

The study of fluid in motion when there is **a significant change in density** **OR** the **Flow at high speed**.
(Examples: Flow in a nozzle, flow of chemical reactant, Turbomachinery)

3. Aerodynamics.

Deals with the motion of **air and other gases**, and their interactions with Bodies in motion such as lift and drag.
(Examples: Automobiles, Aero planes, birds and shockwaves)

Flow Classification

4. Magneto- Hydrodynamic.

The multi-disciplinary study of the flow of **electrically conducting** fluids in **electromagnetic** fields. The fluid flow equations are solved simultaneously with **Maxwell's equations** of electromagnetism.
(Examples of such fluids include plasmas, liquid metals, and salt water).

5. Geophysical Fluid Dynamics.

Fluid phenomena associated with the dynamics of **the atmosphere and the Oceans.**
(Example: Hurricane and Weather Systems.)

6. Bio-fluid Mechanics.

Fluid mechanics involved in biophysical processes such **as blood flow** in arteries and the study of **lungs and their circulatory systems** and many others.

Some applications of Fluid Mechanics

- Flow in pipes, open channels.
- Steam and gas turbines in thermal power stations
- Pumps, Fans and air compressors.
- Weather forecast.
- Tornados and hurricanes.
- Jets and rockets.
- ABS Brakes.
- Waste water treatment technology.
- Wind turbines.
- Lift and Drag.

END

of Chapter One