WEEK 12

Physics of Engineer

Chapter 11: Fluid Mechanics

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Outline

- ❑ What are fluids?
- ❑ Fluid properties
- ❑ Fluid statics (rest fluids)
- ❑ Hydrostatic pressure
- ❑ Buoyancy and Archimedes’principle
- ❑ Fluid kinematics (motion of fluids)
- ❑ The equation of continuity (mass conservation)
- ❑ Fluid dynamics (force and motion)

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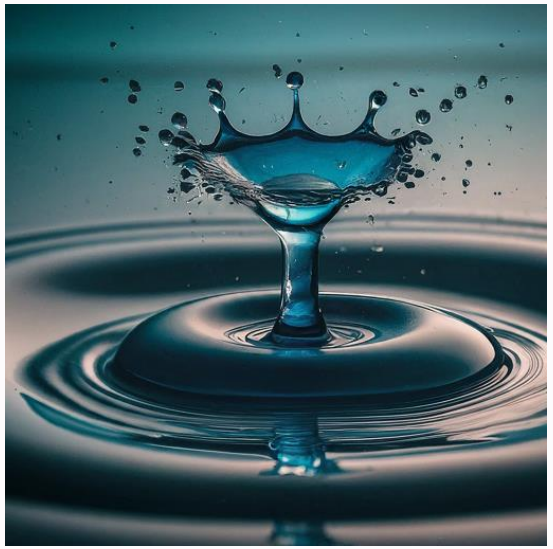
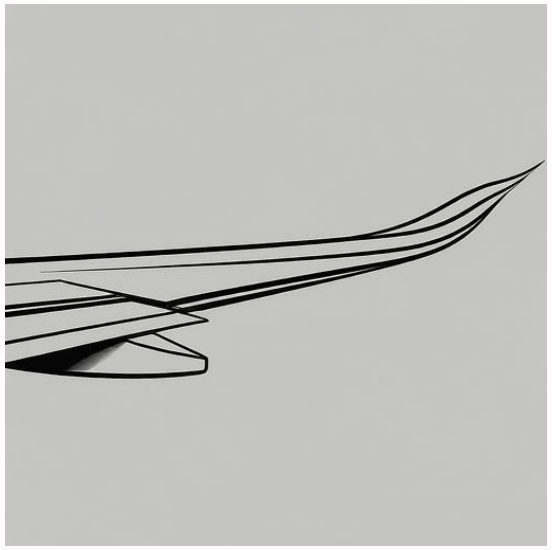
Outline

- ❑ Applications of fluid mechanics in everyday life
- ❑ Conclusion
- ❑ Exploring Resources and references

Fluid Mechanics: Unveiling the Dance of Liquids and Gases





What are Fluids?

- Fluids are substances that deform continuously under applied shear stress.
- Unlike solids, they have no fixed shape and readily flow.
- Fluids can be liquids or gases.
- Liquids have a definite volume but no fixed shape.
- Gases have neither a definite volume nor shape.

Fluid Properties

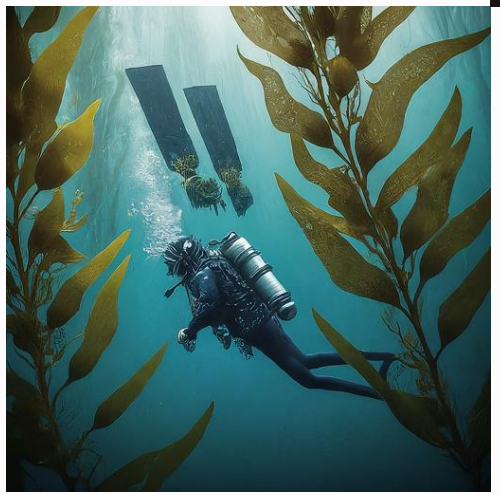
- Several key properties define the behaviour of fluids.
- Density (ρ) : Mass per unit volume (kg/m³)
- Viscosity (μ) : Resistance to flow (N·s/m²)
- Compressibility: Ability to change volume under pressure
- Surface Tension: Tendency of a liquid's surface to minimize its area

Fluid Statics (Resting Fluids)

- Study of fluids at rest
- Pressure (p): Force exerted per unit area (N/m^2) (Pa) (increases with depth in a static fluid)
- Pascal's Law: Pressure applied to a confined fluid is transmitted undiminished throughout the fluid in all directions.

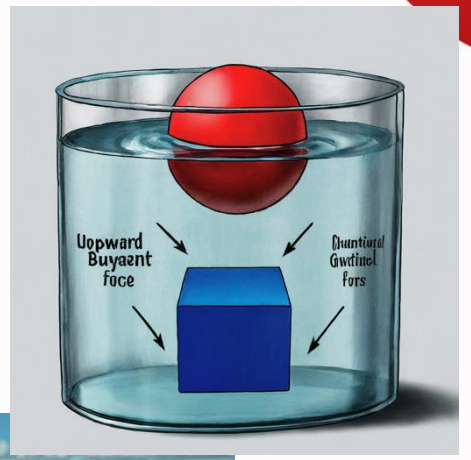
Hydrostatic Pressure

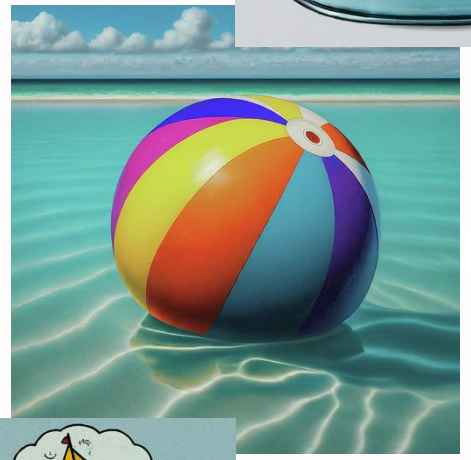
- Content:
  - Pressure due to the weight of a static fluid
  - Relates pressure variation with depth ($p = \rho gh$) [h: depth, g: acceleration due to gravity]



Buoyancy and Archimedes' Principle

- Buoyancy: Upward force exerted on an object submerged in a fluid
- Archimedes' Principle: Buoyant force equals the weight of the fluid displaced by the object





Fluid Kinematics (Motion of Fluids)

- Study of fluids in motion
- Kinematics: Study of fluid motion without considering forces
- Streamlines: Imaginary lines depicting the path of a fluid particle
- Steady Flow: Fluid properties at a point remain constant over time
- Unsteady Flow: Fluid properties at a point change with time

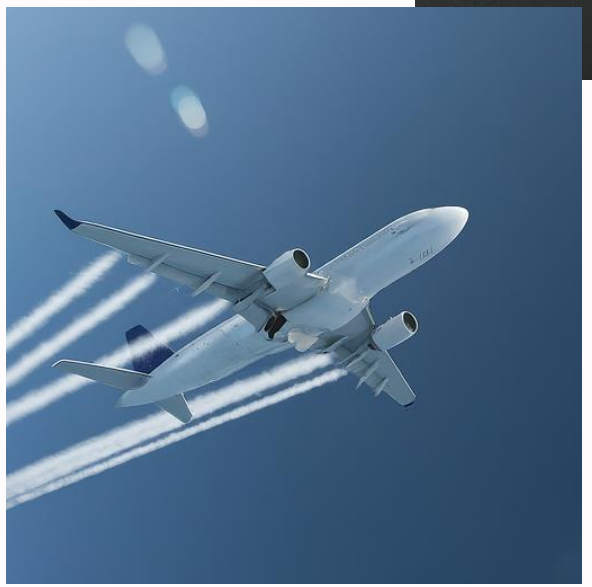



The Equation of Continuity (Mass Conservation)

- A fundamental principle in fluid mechanics.
- Expresses the principle of mass conservation in fluid flow.
- It states that in a steady flow, the mass of fluid entering a control volume must equal the mass of fluid leaving the control volume in a given time interval.

The Equation of Continuity (Mass Conservation)

- **Mathematical Equation:** A ρ (v) = constant
  - A: Cross-sectional area of the flow path
  - **ρ:** Fluid density
  - v: Fluid velocity
- This equation implies that the product of the flow area (A), fluid density (ρ), and fluid velocity (v) at any point in a steady flow remains constant.



Fluid Dynamics (Forces and Motion)

- Dynamics: Analyzes forces acting on fluids and their resulting motion
- Internal Forces: Stresses within the fluid (normal and shear)
- External Forces: Forces acting on the fluid from outside (gravity, pressure)

Applications of Fluid Mechanics in Everyday Life

- Transportation:
  - Designing airplanes, ships, and submarines relies heavily on fluid mechanics principles. Understanding aerodynamics (airflow) is crucial for generating lift on airplane wings, while knowledge of hydrodynamics (water flow) is essential for designing efficient ship hulls and propellers.

- Biomedical Engineering:
  - Fluid mechanics plays a crucial role in understanding blood flow within the human body. By analyzing blood pressure and flow patterns, doctors can diagnose cardiovascular diseases and develop treatment plans.

Conclusion

- Fluid mechanics is a cornerstone of engineering and science, playing a vital role in diverse fields:
  - **Transportation:** Designing aerodynamically efficient airplanes, ships, and submarines.
  - **Biomedical Engineering:** Understanding blood flow patterns for cardiovascular health diagnoses and treatment.
  - **Civil Engineering:** Optimizing plumbing systems in buildings for efficient water distribution.
  - **Weather Prediction:** Analyzing atmospheric fluid dynamics to understand weather patterns and forecast storms.
  - **Sports Science:** Designing sports equipment with optimal aerodynamic properties.
- Beyond these examples, fluid mechanics influences countless aspects of our daily lives, from the way water flows through a garden hose to the intricate dance of air currents shaping weather systems.

Exploring Resources and References

Textbooks:

- "Fundamentals of Fluid Mechanics" by Munson, Young, and Okiishi
- "Introduction to Fluid Mechanics" by Robert W. Fox
- "Fluid Mechanics" by Pijush K. Kundu and Ira M. Cohen

- **Online Resources:**
  - National Aeronautics and Space Administration (NASA) Glenn Research Center: https://www1.grc.nasa.gov/facilities/erb/flow/
  - MIT OpenCourseware: 16.81 Fluid Mechanics https://ocw.mit.edu/search/
  - Khan Academy: Fluid Mechanics https://www.khanacademy.org/science/physics/fluids

- **Journals and Research Papers:**
  - Journal of Fluid Mechanics (https://www.cambridge.org/core/journals/journal-of-fluid-mechanics)
  - Physics of Fluids (https://www.aps.org/meetings/meeting.cfm?name=DFD23)
  - Annual Review of Fluid Mechanics (https://www.annualreviews.org/toc/fluid/current)

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