

CHAPTER 9 | MECHANICAL PROPERTIES OF FLUIDS

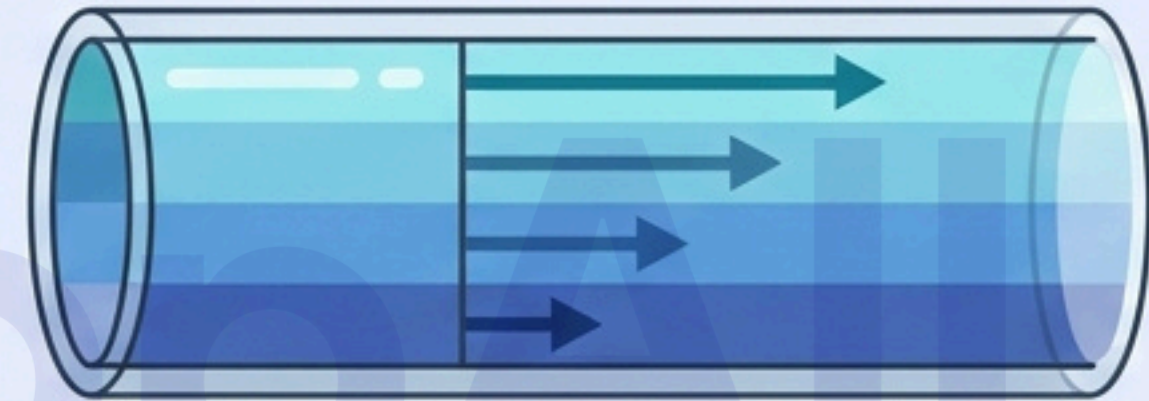
9.5 Viscosity

Understanding internal friction, velocity gradients, and fluid resistance.

Viscosity is 'Internal Friction'



Solid Friction: Opposes relative motion between two solid surfaces.

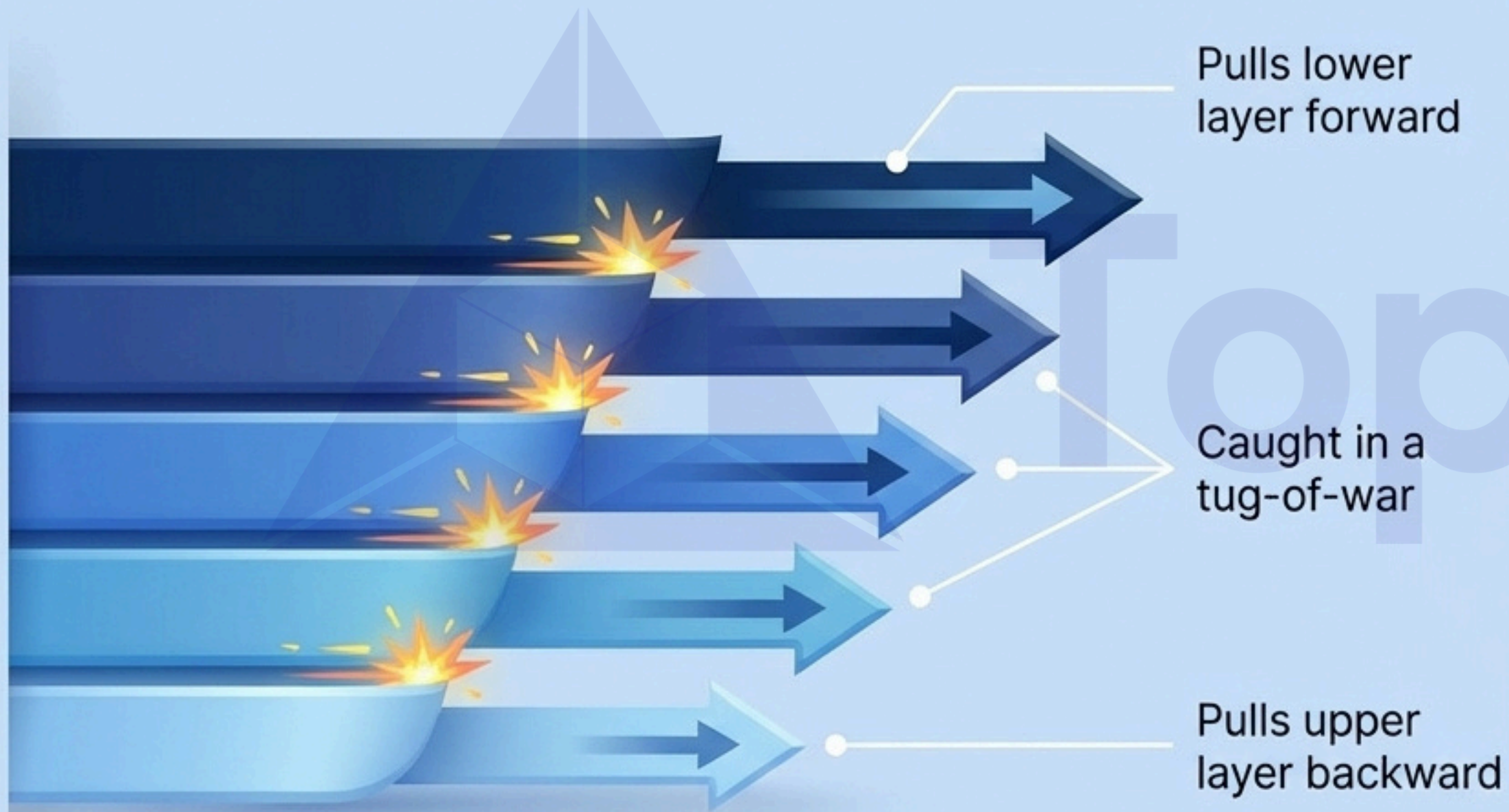


Viscosity (Fluid Friction): Opposes relative motion between different layers of a fluid.

- Most real-world fluids are not ideal and offer resistance to motion.
- Viscosity acts like an **internal drag force** within the fluid itself.

LAMINAR FLOW

How Fluid Layers Interact



- Fluids flow in smooth parallel layers (laminar flow).
- Fast-moving upper layers try to accelerate lower layers.
- Slow-moving lower layers try to drag upper layers backward.
- Result: A continuous internal frictional force.



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$$E=mc^2$$



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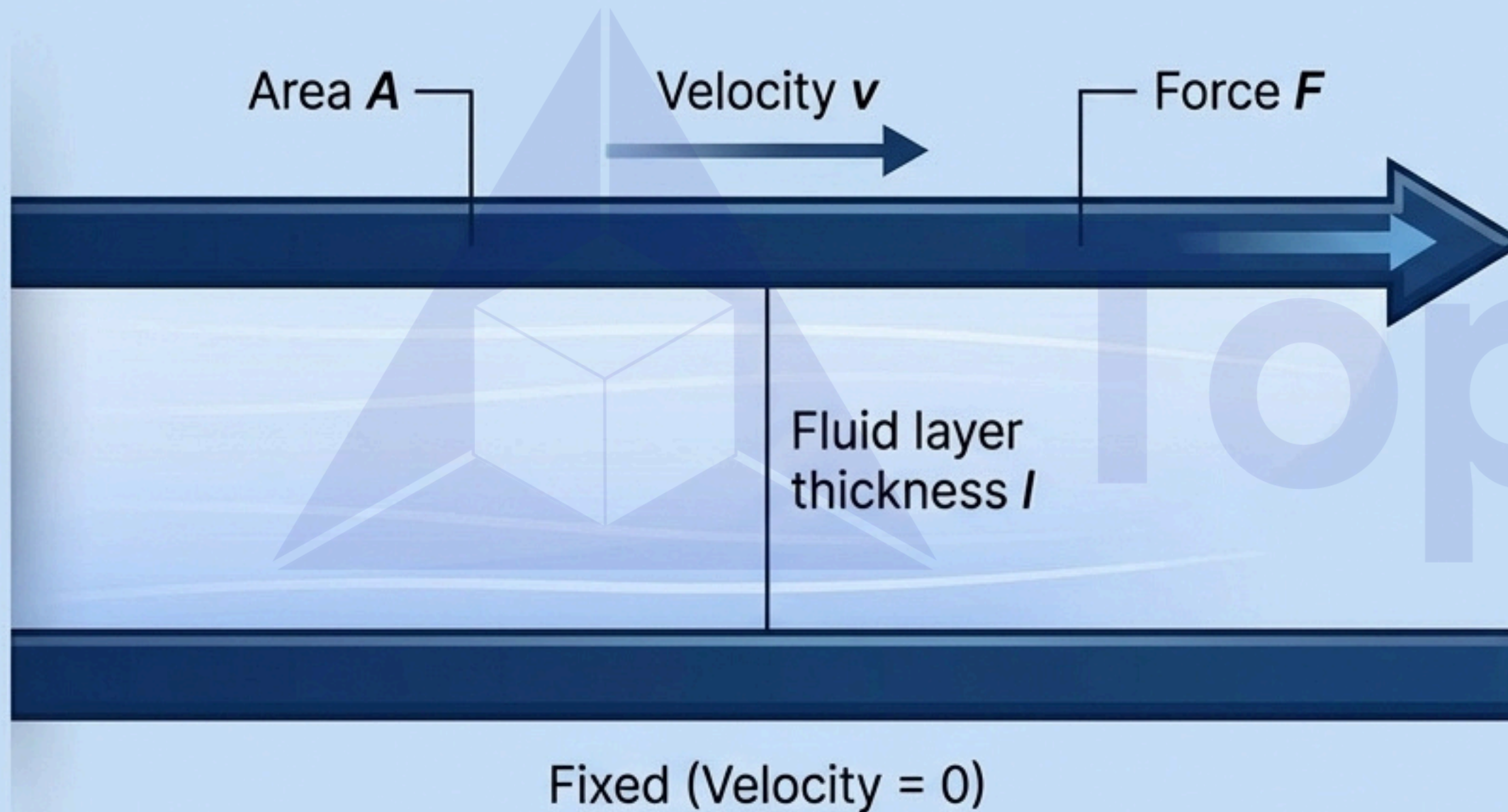
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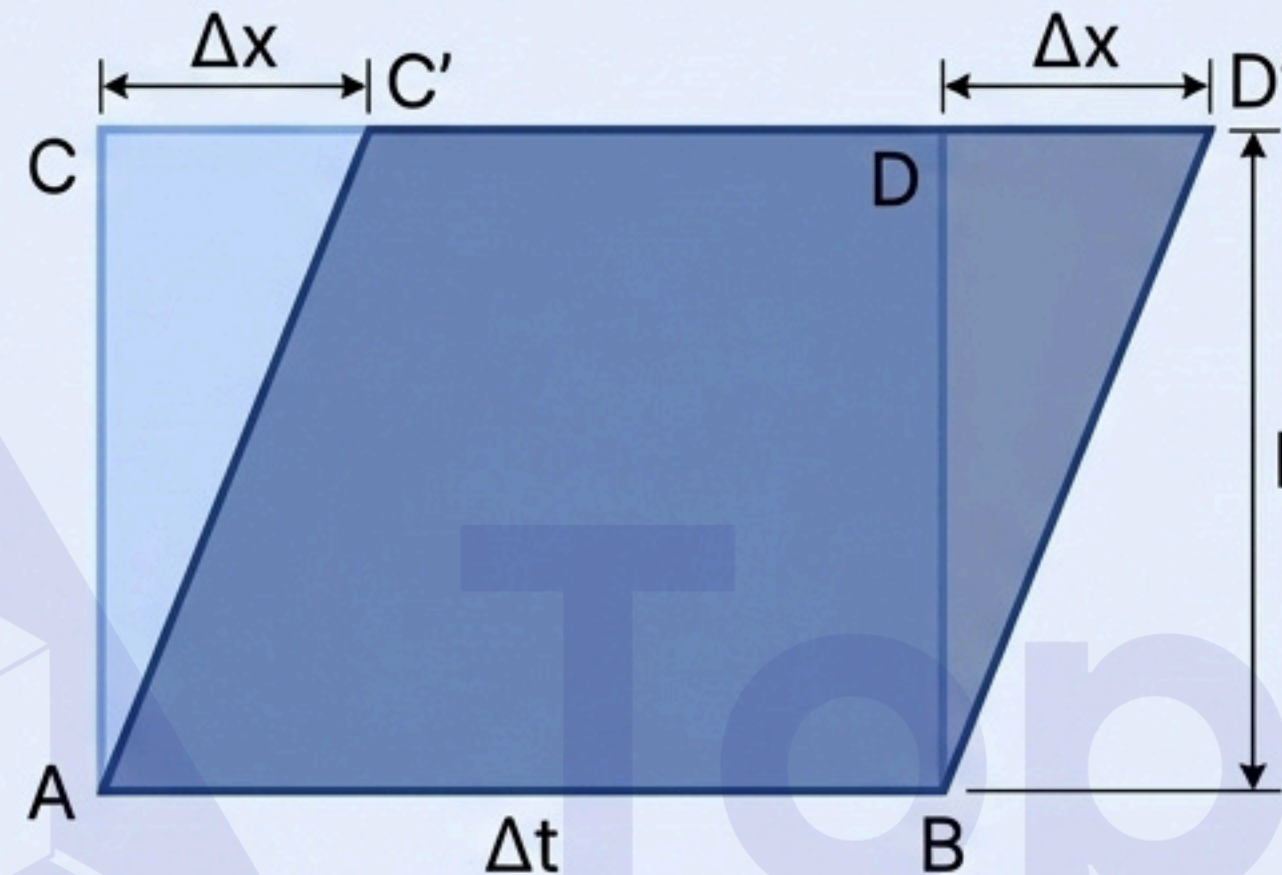
FIGURE 9.12(a) REDRAW

Trapping Fluid Between Plates



- No-Slip Condition: Fluid touching a surface moves at the exact same velocity as that surface.
- The top layer moves at v ; the bottom layer rests at 0 .
- Velocities increase uniformly from the bottom to the top.

The Velocity Gradient



$$\text{Strain Rate} = \frac{\Delta x}{l \cdot \Delta t} = \frac{v}{l}$$

- Unlike solids, fluids do not have a fixed strain—their strain increases continuously over time.
- Fluid stress depends on the rate of shear strain (how fast it deforms).
- **Velocity Gradient** (v/l): The change in velocity per unit perpendicular distance between layers.



Honey

- **High Viscosity** ("Thick")
- Requires a greater force to move the top plate at velocity v .



Oil

- **Low Viscosity** ("Thin")
- Requires a smaller force to move the top plate at velocity v .

Coefficient of Viscosity (η)

$$\eta = \frac{\text{Shearing Stress}}{\text{Strain Rate}} = \frac{F/A}{v/l} = \frac{F \cdot l}{v \cdot A}$$

Key Takeaways

- **Viscosity:** The internal friction resisting relative motion between fluid layers.
- **Formula:** $\eta = (F \cdot l) / (v \cdot A)$
- **SI Unit:** poiseuille (Pl) or Pa·s or N·s·m⁻².
- **Dimensions:** [M L⁻¹ T⁻¹].
- **Temperature Effect:** Viscosity decreases in liquids and increases in gases as temperature rises.

[Start Practice: Chapter 9 MCQs →]



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