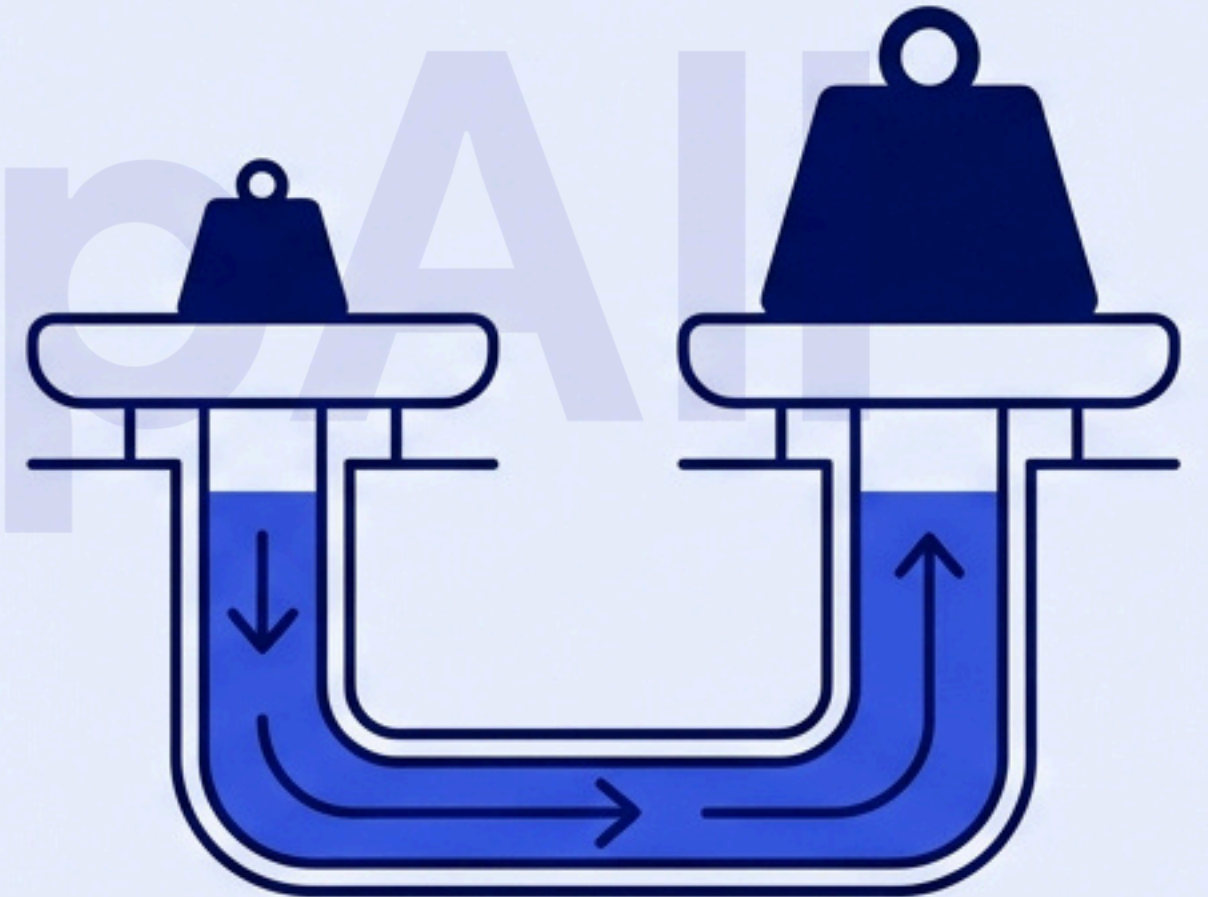


CLASS 11 PHYSICS • CHAPTER 9

9.2.4 Hydraulic Machines

Mastering Pascal's Law for Force Multiplication

NEET / JEE Prep Module



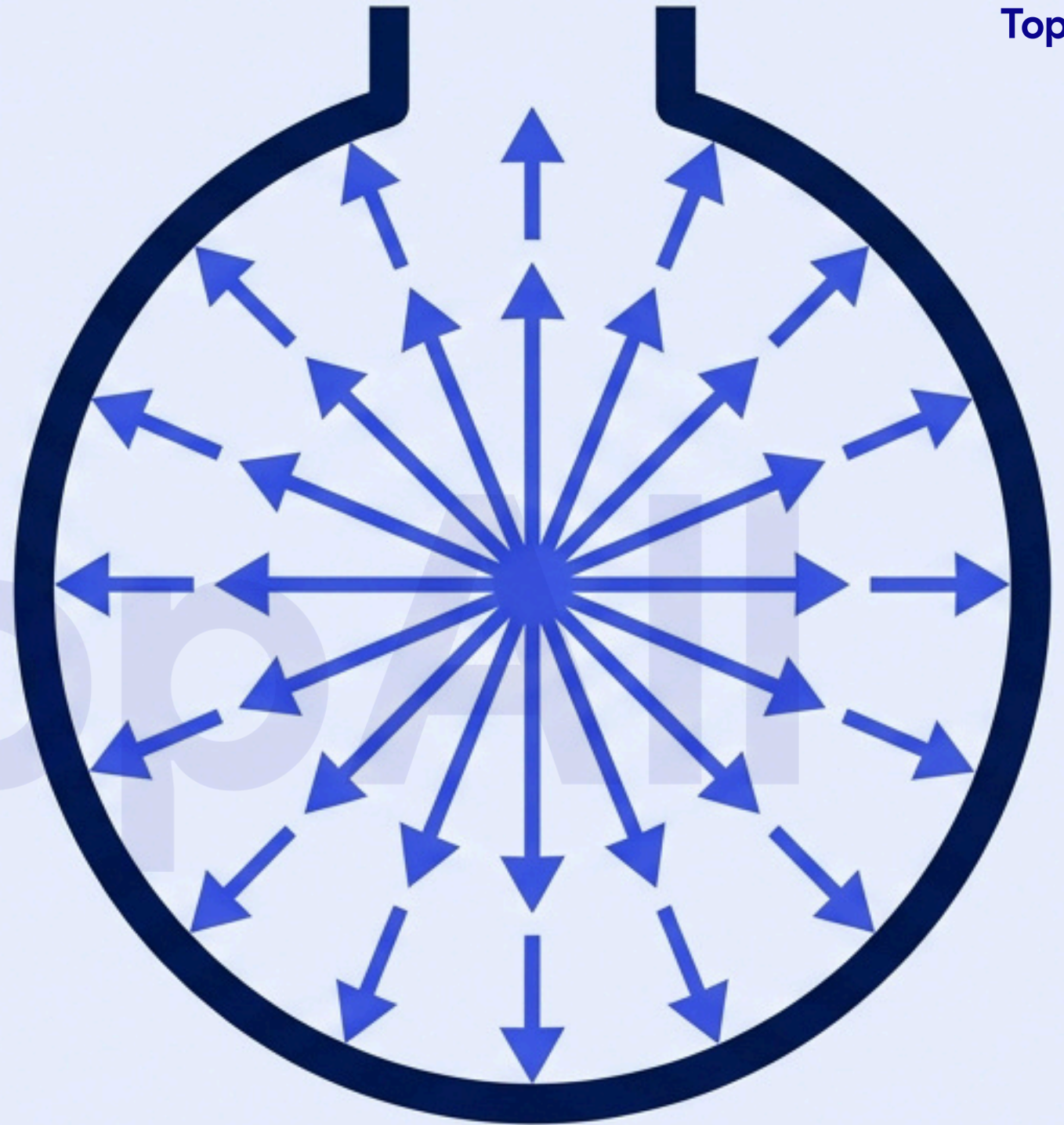
PHYSICS PRINCIPLE

Pressure in an Enclosed Fluid

Whenever external pressure is applied on any part of a fluid contained in a vessel, it is transmitted undiminished and equally in all directions.

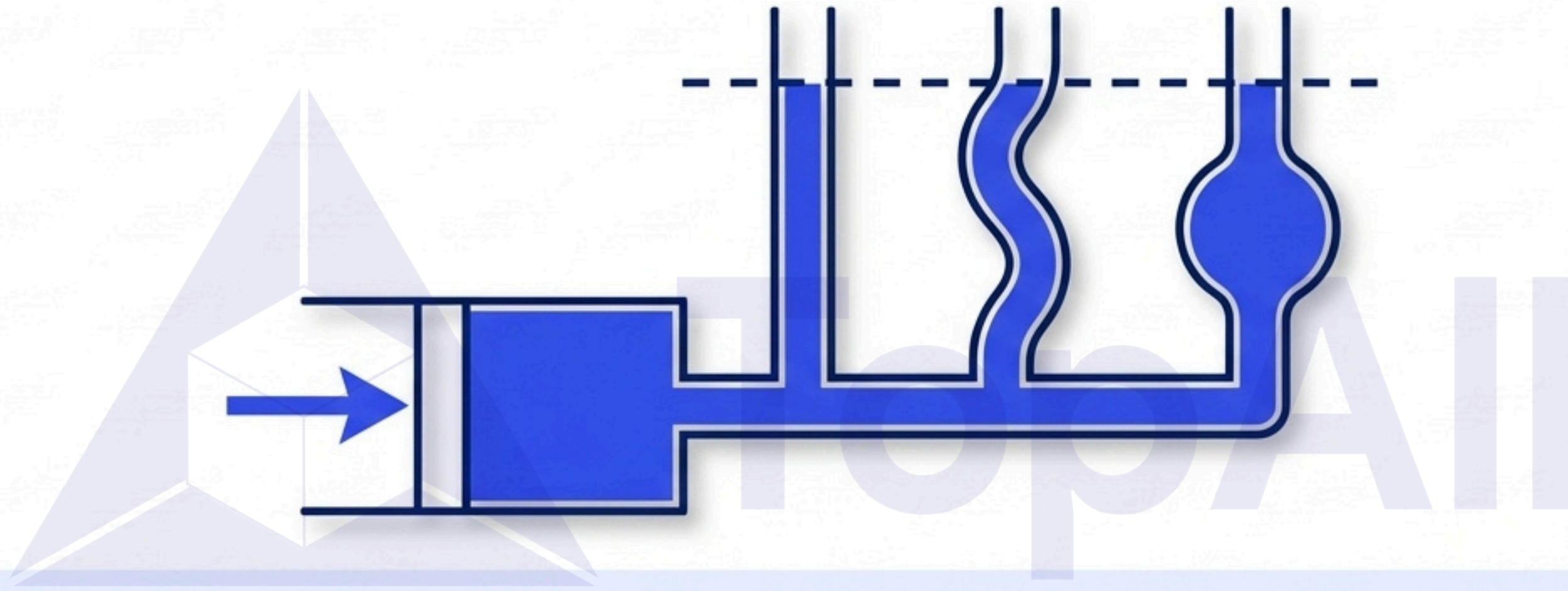
- This is a practical application of Pascal's Law.
- The fluid acts as a perfect medium for transmitting pressure.
- This is the basis for all hydraulic devices.

💡 **EXAM TIP:** Applies strictly to incompressible fluids at rest.



Visualizing Pressure Transmission

FIGURE 9.6(a) REDRAW



- Pushing the piston increases pressure inside the horizontal cylinder.
- The fluid level rises equally in all vertical tubes.
- **Conclusion:** The pressure is distributed uniformly throughout the entire system.



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$$E=mc^2$$



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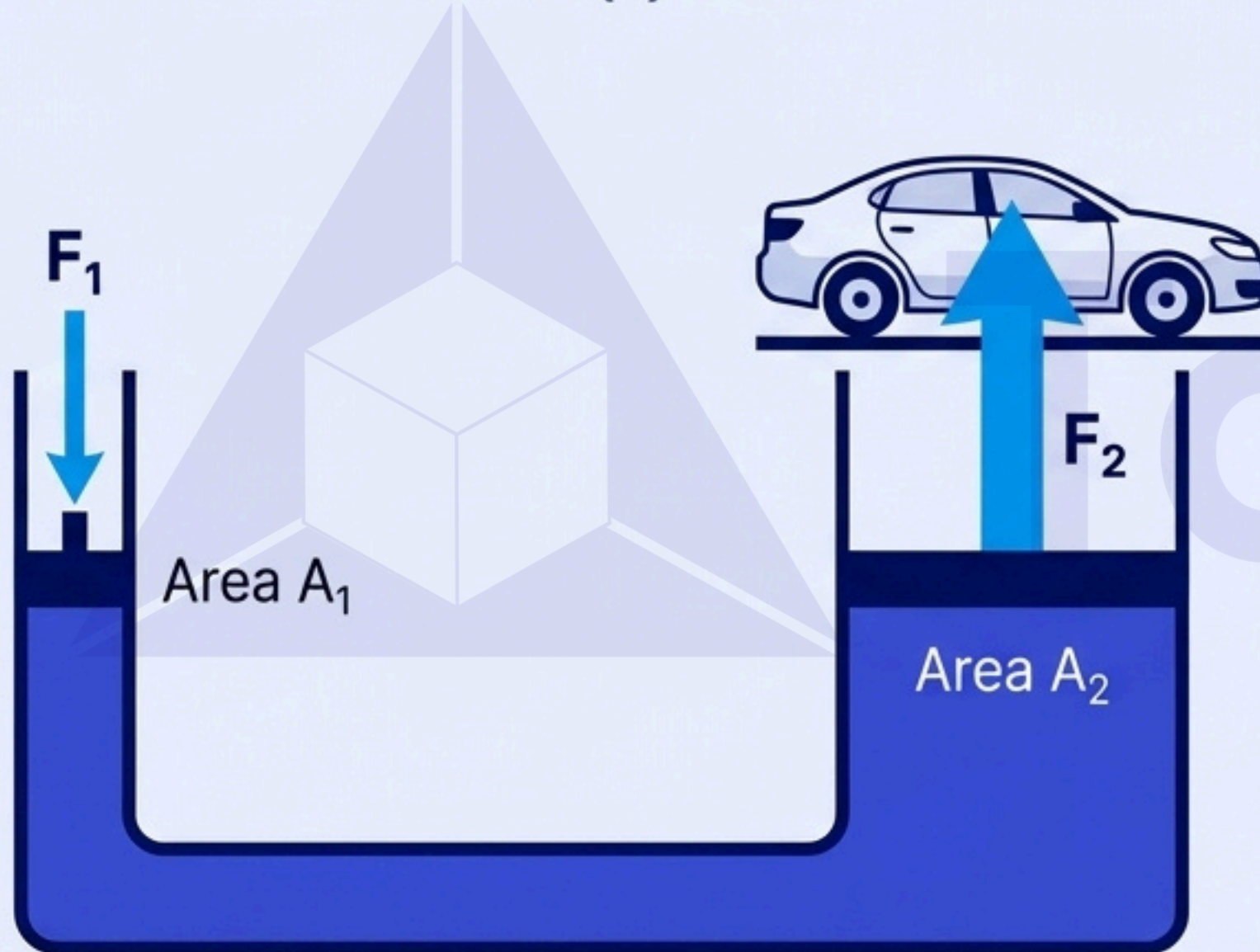
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H2: The Hydraulic Lift Setup

FIGURE 9.6(b) REDRAW



- Two pistons are separated by a space filled with liquid.
- A small force (F_1) is applied to the small piston (A_1).
- The exact same pressure (P) travels through the fluid to the large piston (A_2).
- The result is a massive upward force (F_2) capable of lifting heavy loads.

Deriving the Output Force

MATHEMATICAL DERIVATION

Step 1: Input Pressure $\rightarrow P = \frac{F_1}{A_1}$

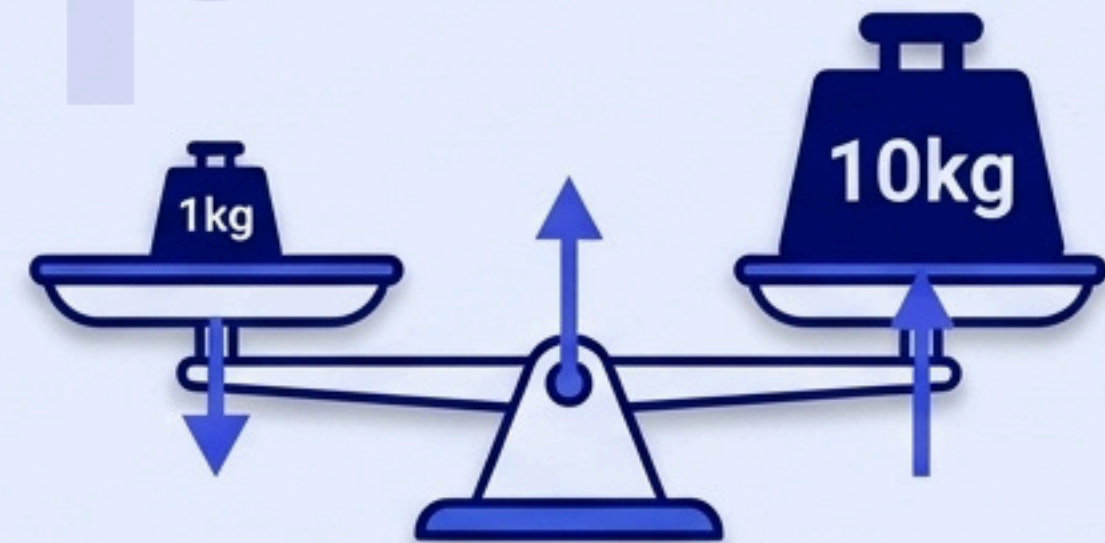
Step 2: Transmitted Force $\rightarrow F_2 = P \times A_2$

Step 3: Final Equation $\rightarrow F_2 = F_1 \left(\frac{A_2}{A_1} \right)$

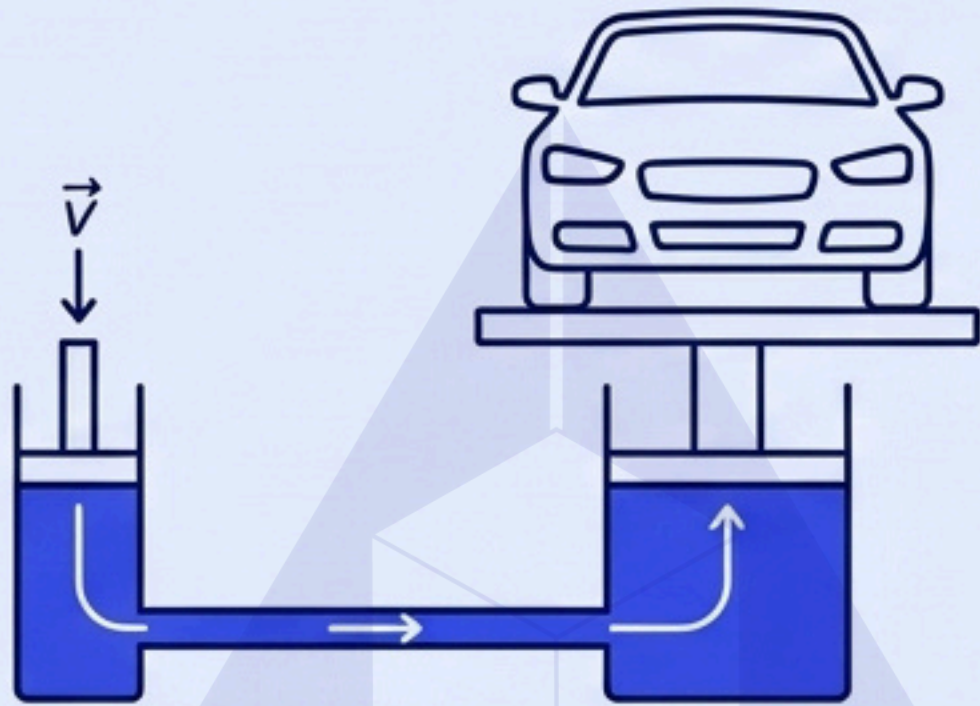
Mechanical Advantage

$$\text{Advantage} = \frac{A_2}{A_1}$$

Because $A_2 > A_1$, the applied force is multiplied by this exact factor.

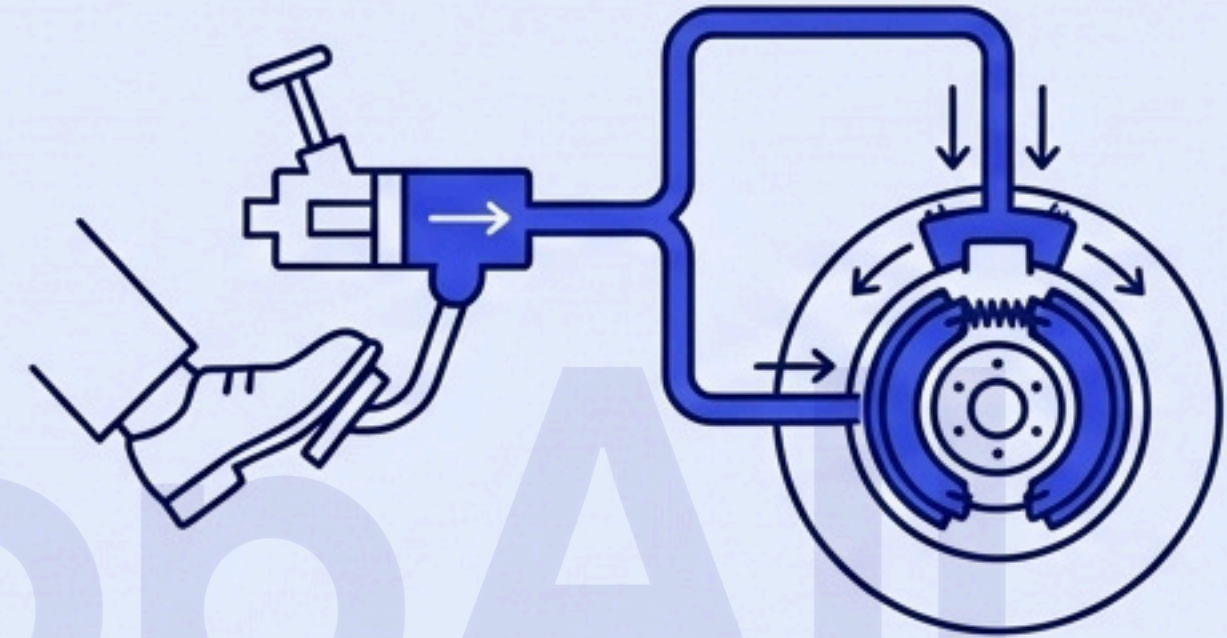


Hydraulics in Action



Hydraulic Lifts

- Used in automobile service stations.
- A small motor pushes a narrow piston.
- Lifts a heavy vehicle (e.g., 3000 kg) on the wide platform easily.



Hydraulic Brakes

- A small force on the foot pedal translates to a master cylinder.
- Pressure is transmitted equally to all four wheels.
- Ensures synchronized and equal braking effort across the entire vehicle.

Chapter 9.2.4 Wrap-Up



Key Takeaways

- ✓ Pressure applied to an enclosed fluid is transmitted equally and undiminished.
- ✓ Hydraulic machines work by transferring this pressure from a small area to a large area.
- ✓ The core formula $F_2 = F_1 (A_2 / A_1)$ dictates the exact force multiplication.
- ✓ Mechanical Advantage depends strictly on the ratio of the two piston areas.

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