

[CHAPTER 11: THERMODYNAMICS]

11.8.1 Quasi-Static Process

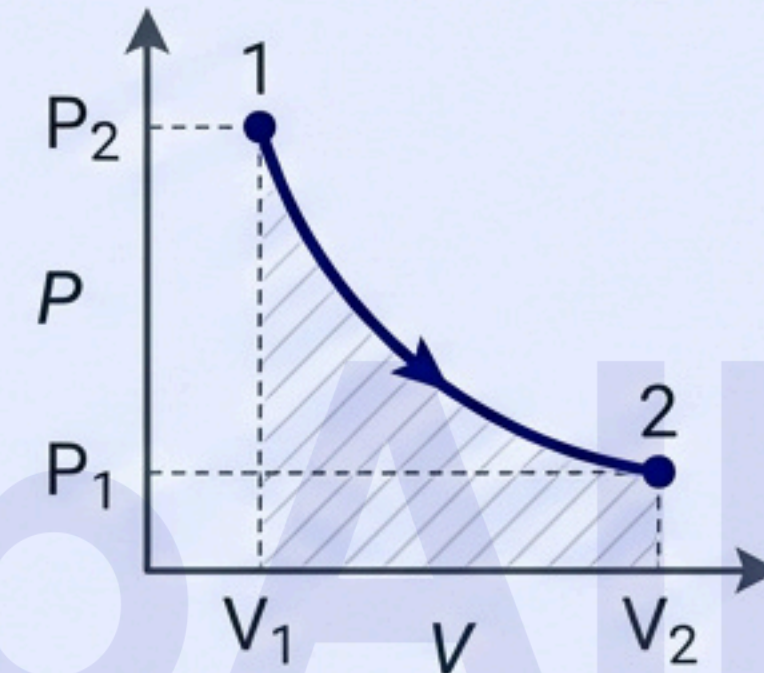
Understanding Infinitely Slow
Thermodynamic Idealizations

The Problem With Sudden Changes



Messy Reality

- System passes through non-equilibrium states.
- Pressure and temperature are not uniform throughout the gas.
- State variables (P , V , T) cannot be well-defined or calculated.



The Solution

- We need an idealized process where the system is in an equilibrium state at every stage.
- This allows us to track the exact path of the thermodynamic process.

Defining the Quasi-Static Process

A hypothetical construct where a process is infinitely slow, allowing the system to remain in thermal and mechanical equilibrium with its surroundings at all times.

QUASI (Nearly)

The variables change by an infinitesimally small amount.

STATIC (Stationary)

The system appears stationary because the changes are so minute.



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$$E=mc^2$$



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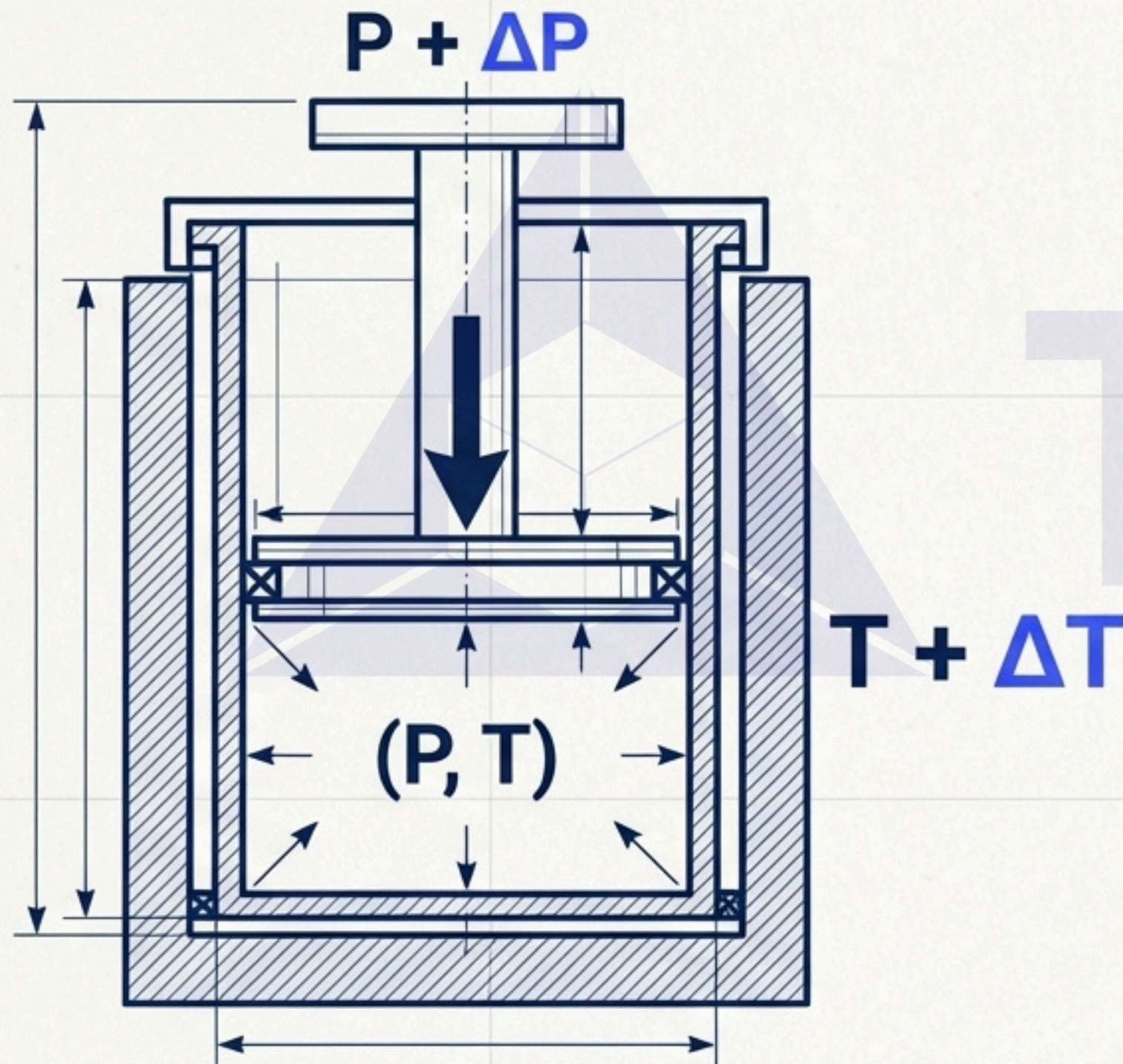
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The Idealized System



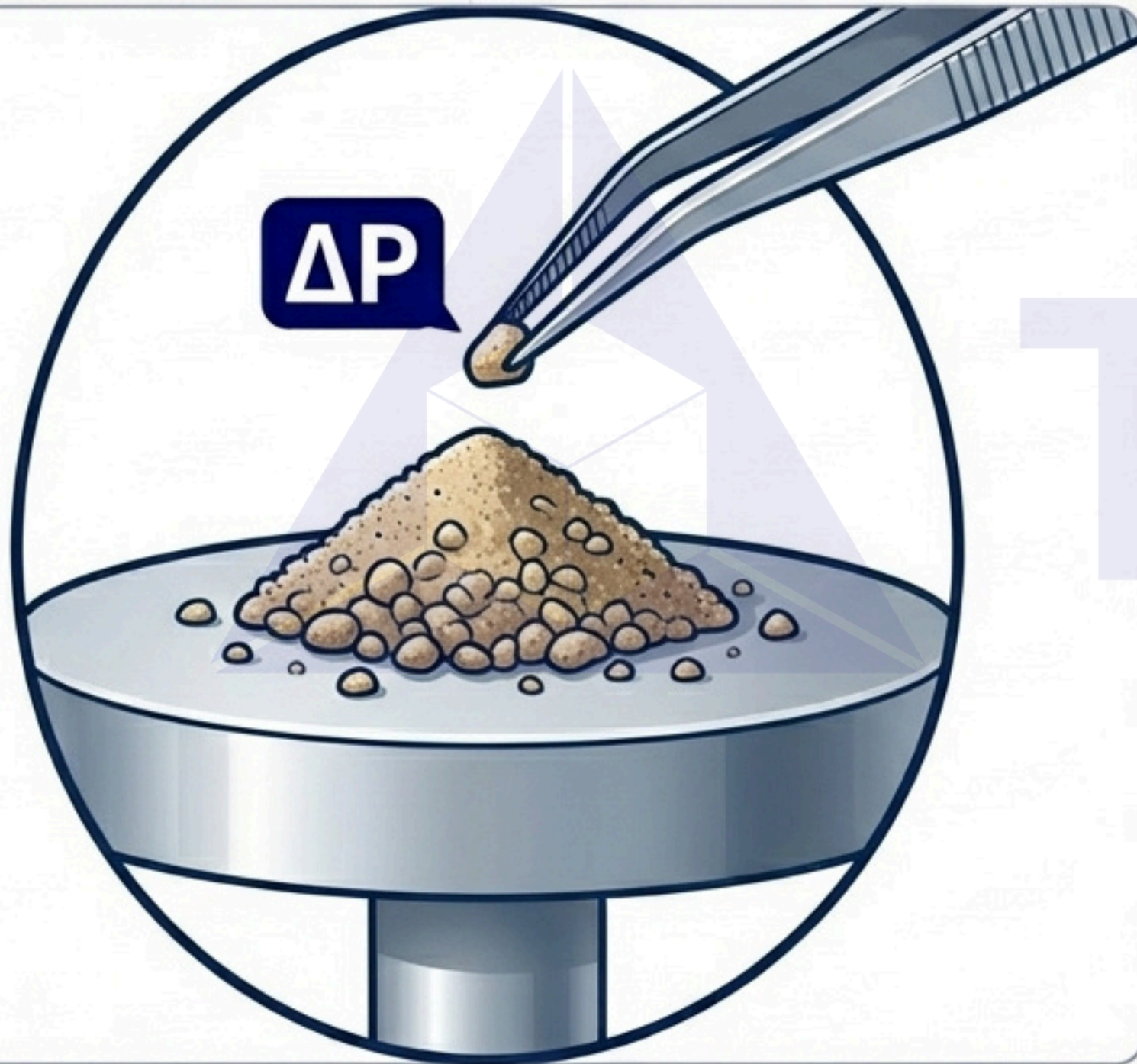
System State: Gas is at uniform pressure P and temperature T .

External Environment: Surrounding reservoir is at $T + \Delta T$ and external pressure is $P + \Delta P$.

The Crucial Detail: ΔP and ΔT are infinitesimally small differences.

Maintaining Mechanical Equilibrium

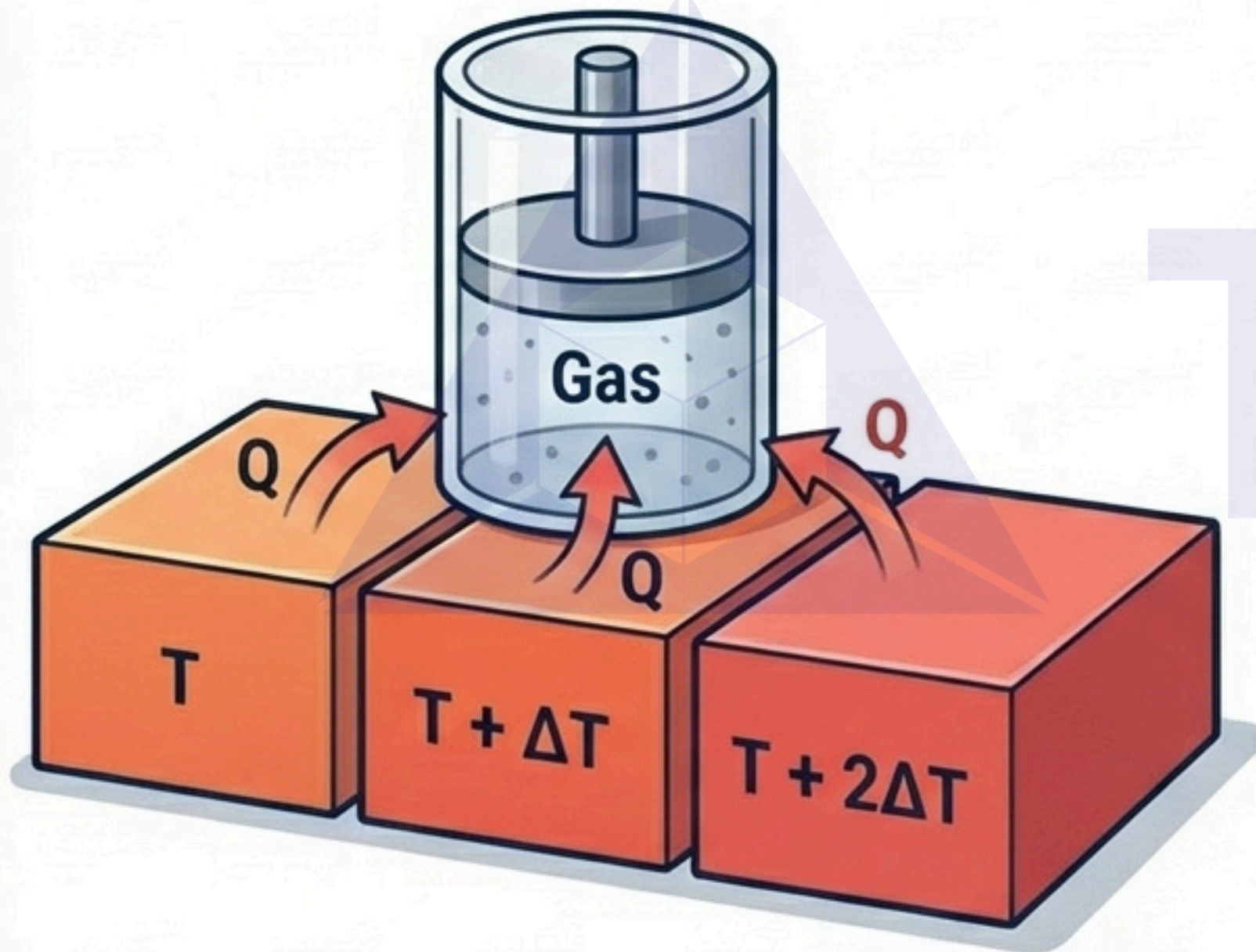
The external pressure differs by only ΔP



- To change the volume, external pressure is changed by a very small amount ($\Delta P \rightarrow 0$).
- The system is allowed to equalize its pressure with the surroundings before the next change.
- **Result:** No accelerated motion of the piston; the system is mechanically balanced at every single stage.

Maintaining Thermal Equilibrium

The reservoir temperature differs by only ΔT



- To change the temperature, we introduce an infinitesimal difference ($\Delta T \rightarrow 0$) between the system and reservoirs.
- Heat is exchanged infinitely slowly without creating large temperature gradients.
- **Result:** The gas temperature is perfectly uniform at every moment; no hot or cold spots.

[KEY TAKEAWAYS]



Module Summary

1. A quasi-static process is an idealized, hypothetical construct that operates infinitely slowly.
2. The system remains in complete thermal and mechanical equilibrium with its surroundings throughout the entire process.
3. The driving differences in pressure (ΔP) and temperature (ΔT) between the system and surroundings are always infinitesimally small.

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