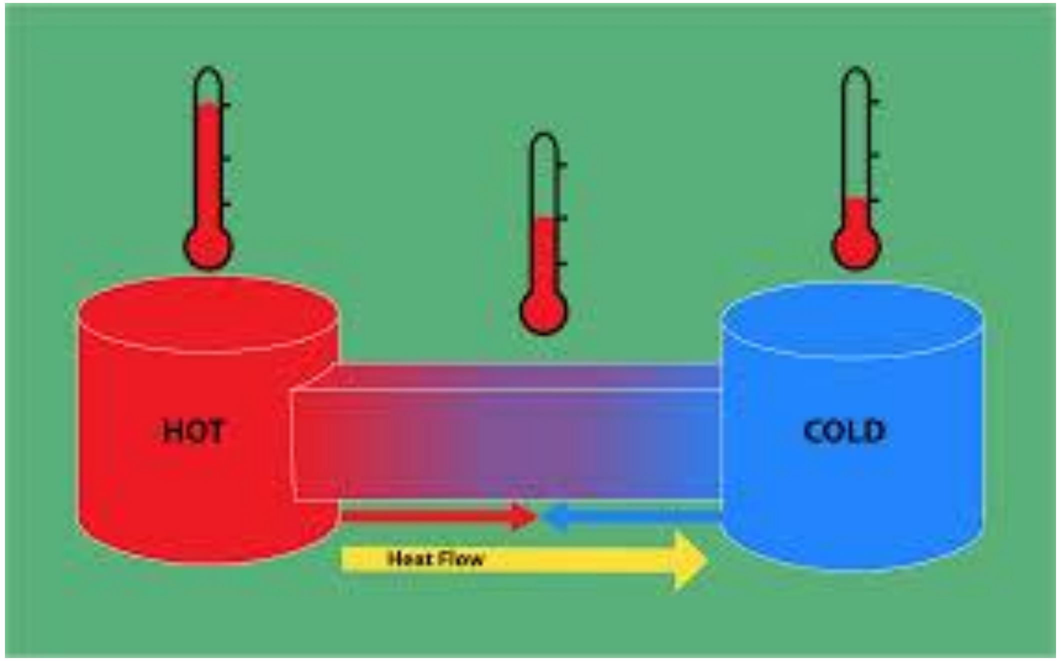
ZEROTH LAW AND FIRST LAW OF THERMODYNAMICS



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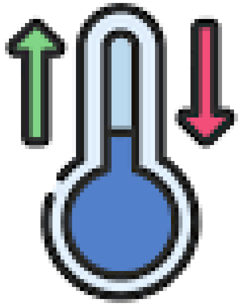
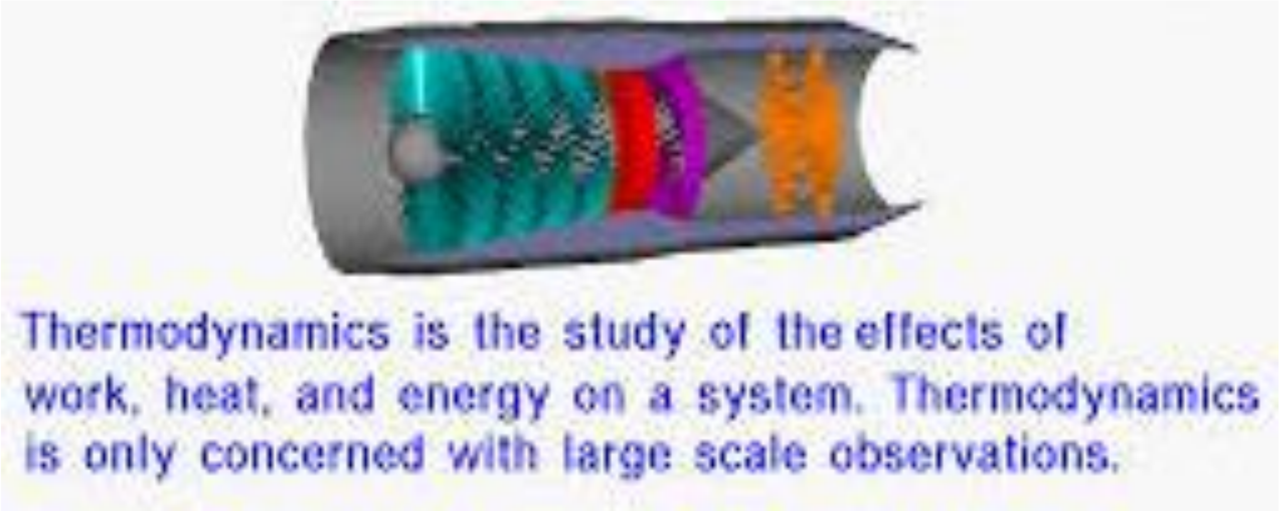
What is Thermodynamics

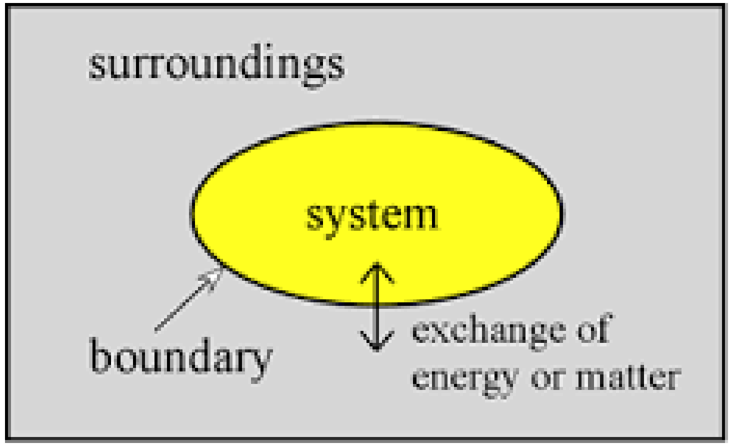


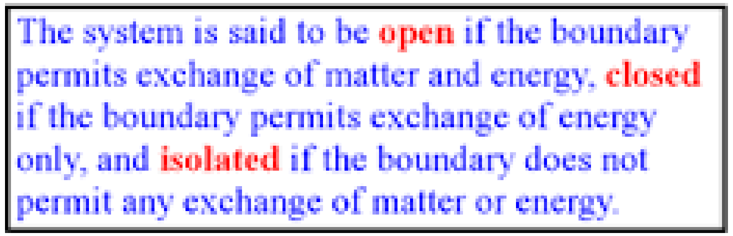
Basic Concept of Thermodynamics

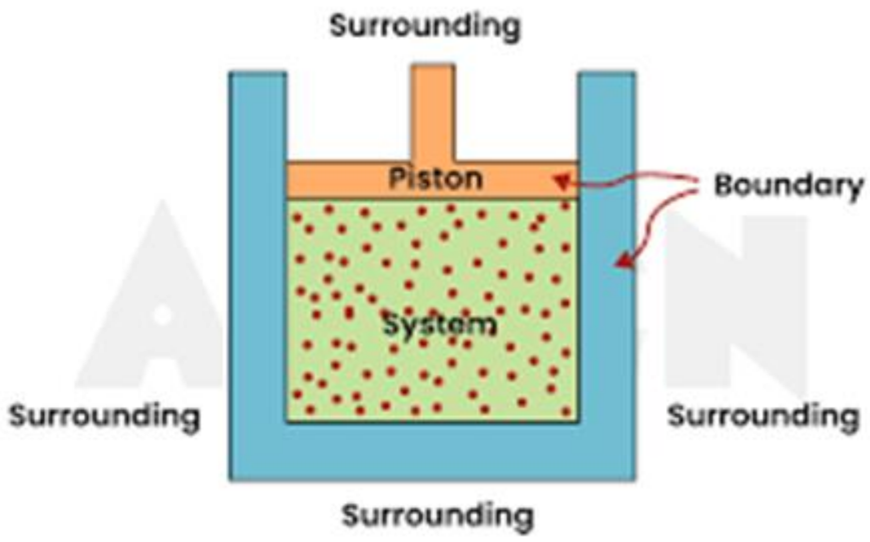


System

•The system is a specific region of space or quantity of matter
•The system can be open, closed, or isolated
•The system can exchange energy and matter with its surroundings




The system is said to be open if the boundary permits exchange of matter and energy, closed if the boundary permits exchange of energy only, and isolated if the boundary does not permit any exchange of matter or energy.



Thermodynamical System

Surroundings

•The surroundings are everything outside the system
•The surroundings can interact with the system by exchanging energy and matter
•The surroundings can also be called the environment or reservoir

Boundary

•The boundary is the surface that separates the system and its surroundings
•The boundary can be real or imaginary, fixed or movable, rigid or flexible

Zeroth Law of Thermodynamics

(Understanding the Foundations of Thermal Equilibrium)

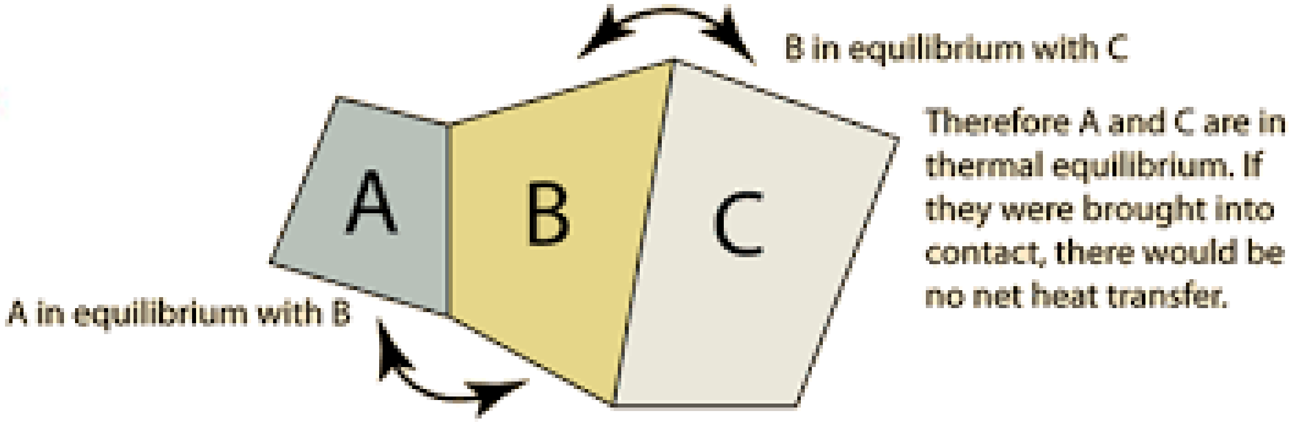
The Zeroth Law of Thermodynamics states that if two thermodynamic systems are each in thermal equilibrium with a third system, they are in thermal equilibrium with each other. This foundational principle allows us to define temperature in a meaningful way, establishing a basis for temperature measurement.

- Consider 3 Objects, **A, B C:**

"If A is in thermal equilibrium with B & if B is in thermal equilibrium with C, then A is in thermal equilibrium with C".

- In terms of system **Temperatures:**

If $T_A = T_B$ & $T_B = T_C$, then $T_A = T_B$.



The term 'Zeroth Law' was introduced after the First and Second Laws of Thermodynamics were established, to provide clarity on the concept of temperature. It emerged in the mid-20th century as scientists recognized the need for a foundational principle to support the existing laws, enhancing the understanding of thermal interactions between systems.

The Zeroth Law of Thermodynamics is crucial as it provides a coherent framework for understanding thermal equilibrium, allowing scientists and engineers to compare and measure temperature in various systems. Its principles underpin much of the theory in thermodynamics and establish the foundational relationship between heat and energy transfer, contributing to advancements in countless scientific fields.

Real-world Examples OF Zeroth Law

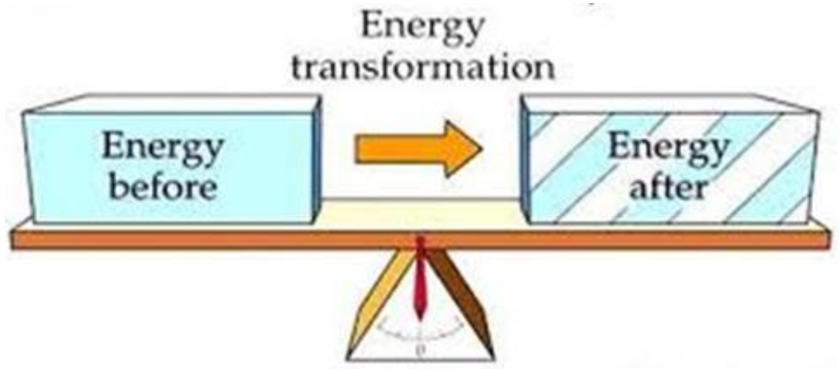
One of the primary applications of the Zeroth Law is in temperature measurement, where it enables the use of thermometers. If two systems are in thermal equilibrium with a thermometer, they will have the same temperature. This relation is fundamental in the calibration and design of temperature measurement devices, ensuring their accuracy for scientific and practical purposes.

In practice, the Zeroth Law is observed in various real-world scenarios. For example, when you place a hot cup of coffee in a cooler room, it eventually reaches thermal equilibrium with the room's air temperature. Additionally, industrial temperature control systems rely on these principles to ensure that materials are maintained at desired temperatures during processing.

The Zeroth Law also plays a crucial role in establishing thermodynamic equilibrium among systems. When multiple systems reach thermal equilibrium, their energy states stabilize, allowing for the assessment of energy transfer processes. This understanding is essential in designing efficient thermal systems in engineering, HVAC, and energy management.

First Law of Thermodynamics

The First Law of Thermodynamics states that energy cannot be created or destroyed in an isolated system. Instead, the total energy is conserved, meaning it can only change forms, such as converting heat into work or vice versa. This principle lays the groundwork for understanding how energy transfers occur in physical systems.



Key concepts related to the First Law

- Internal energy (U) refers to the total energy contained within a system.
- ΔU refers to change in internal energy.
- Heat (Q) is the energy transfer due to temperature differences.
- Work (W) is the pressure-voulume work done due to the expansion or compression of a gas.

Together, these concepts explain how energy conservation governs various thermodynamic processes.

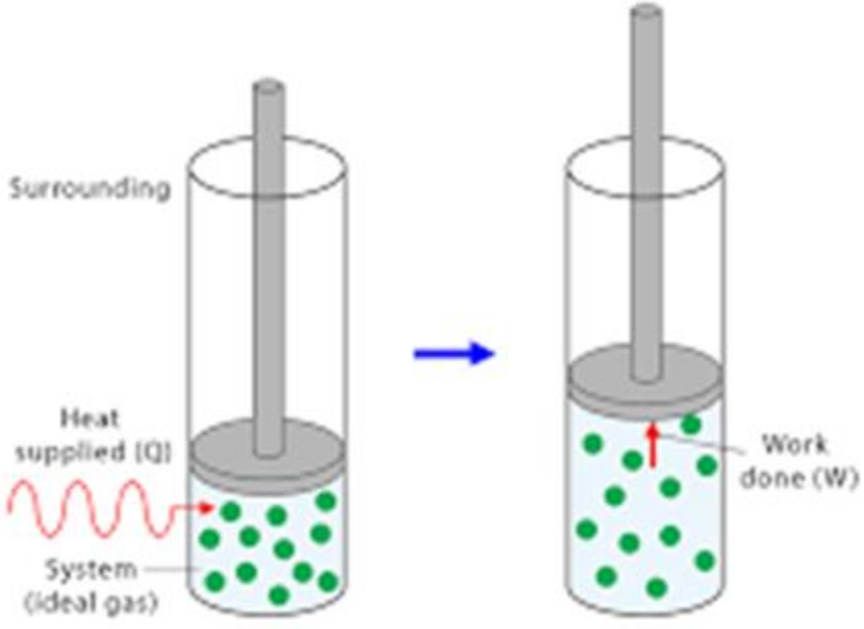
First Law of Thermodynamics

sign conventions

1.	If heat is absorbed by the system	:	$+q$
2.	If heat is evolved by the system	:	$-q$
3.	work is done by the system	:	$-w$
4.	work is dne on the system	:	$+w$

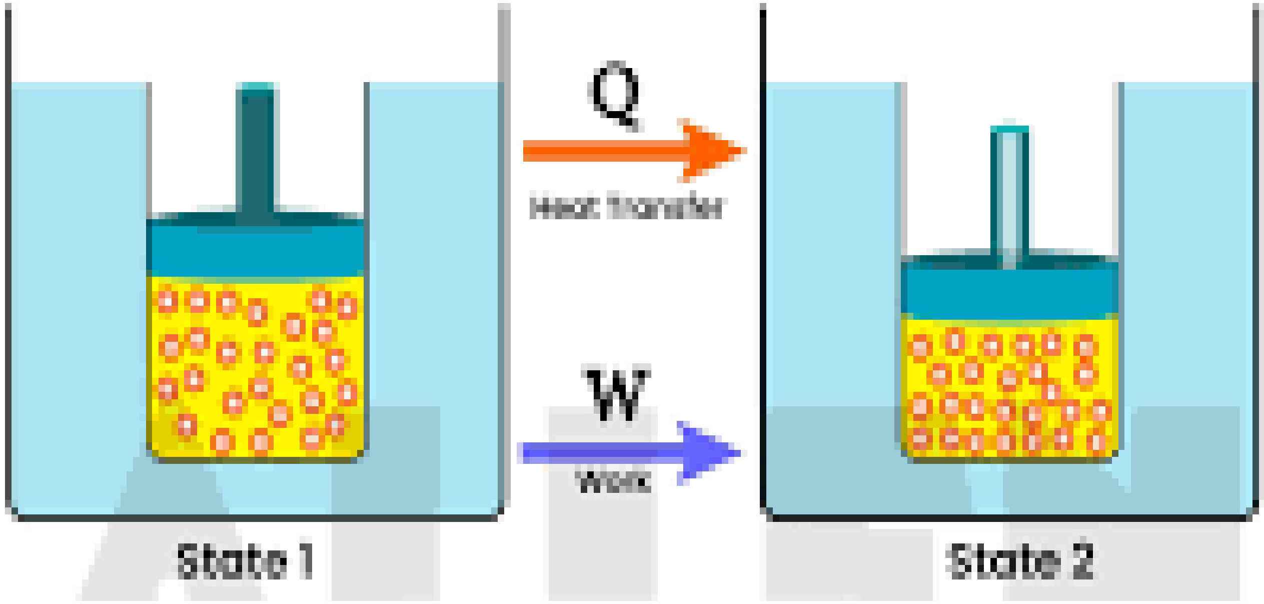
EXPANSION OF A GAS (WORK DONE BY THE SYSTEM)

The change in internal energy (ΔU) of a system equals to the heat added to the system minus the work done



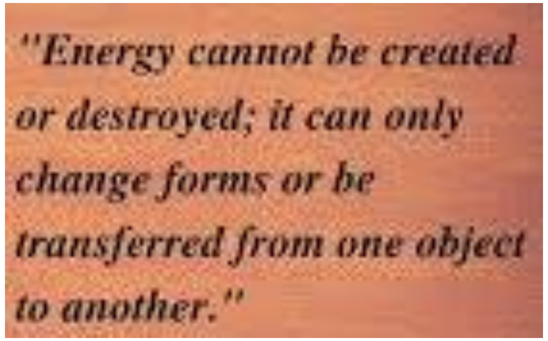
$$\Delta U = Q - W$$

COMPRESSION OF A GAS (WORK DONE ON THE SYSTEM)



$$\Delta U = q + W$$

Importance of First Law of Thermodynamics



The First Law of Thermodynamics is foundational to the field of thermodynamics. It explains energy conservation in physical processes, guiding engineers and scientists in creating efficient systems. Understanding this law allows for advancements in technology, including energy generation and thermal management. It lays the groundwork for the other laws of thermodynamics and is crucial in designing systems like engines and refrigerators, ensuring they operate within energy constraints.

Real-world Examples

Real-world applications of the First Law of Thermodynamics span various industries.

- In thermal power plants, the combustion of fuel generates steam, converting thermal energy into electricity, embodying energy transformation principles.
- In HVAC systems, understanding energy flow ensures optimal functioning, reducing energy consumption.
- Other examples include cooking methods, where heat is transformed into food energy.
- In automotive engines, where fuel combustion drives mechanical motion, showcasing the law's impact on everyday life.

Real-world Examples

Heat Engines

Heat engines convert thermal energy into mechanical work by using heat from fuel combustion. The First Law dictates that input energy is equal to the work done plus the heat expelled. This principle governs the efficiency of engines, such as car engines and power plants, highlighting the significance of using energy resources wisely to minimize waste and enhance performance. The understanding of thermodynamic cycles, like Carnot or Otto cycles, comes from this law.

Refrigeration

Refrigeration systems operate on the principle of the First Law by removing heat from a designated area to maintain lower temperatures. Using a refrigerant, these systems cycle between absorbing heat from inside a refrigerator and expelling it outside. The law emphasizes that work must be done on the system, typically by a compressor, to achieve this heat transfer. This principle is central in the engineering of air conditioning and refrigeration units, influencing energy consumption and efficiency.

Conclusions

- The Zeroth Law of Thermodynamics is foundational for the understanding of thermal systems, temperature measurement, and thermodynamic equilibrium. Its applications extend across various scientific and engineering disciplines, illustrating its significance in both theoretical and practical contexts.
- The First Law of Thermodynamics is a vital principle that underscores the conservation of energy in various systems. Its understanding is crucial for advancements in technology, enhancing efficiency in applications such as engines and refrigeration.

By recognizing the interplay between heat, work, and energy, we can improve energy usage and management across multiple sectors, paving the way for a more sustainable future.