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BASIC THERMODYNAMICS

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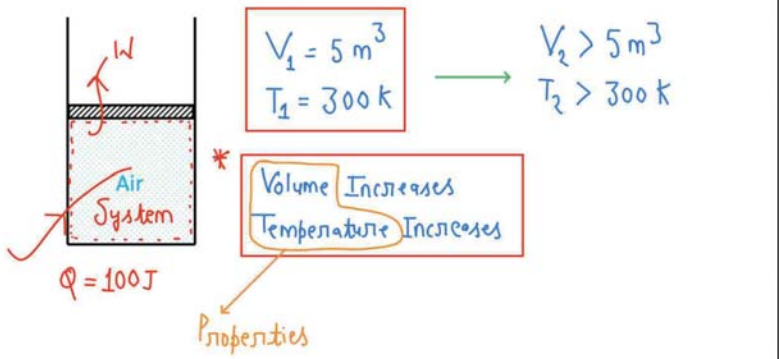



## Thermodynamics

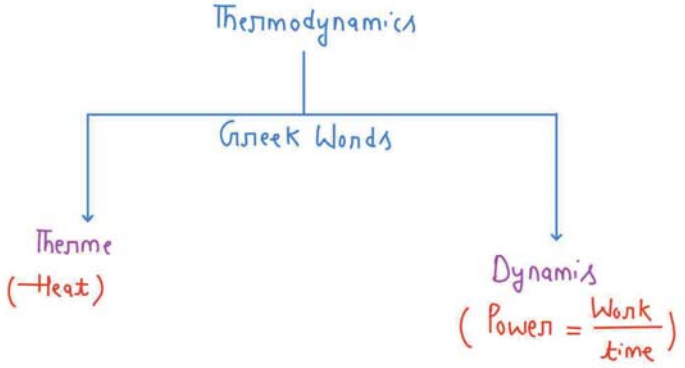
Thermodynamics ⟶ Lord Kelvin (1849)

First Textbook on Thermodynamics ⟶ William Rankine (1859)

Thermodynamics word was first introduced by Lord Kelvin in 1849.

First textbook on Thermodynamics was written by William Rankine in 1859.

Thermodynamics deals with the energy interactions ( heat and work interactions ) and its effect on properties of the system.




Content

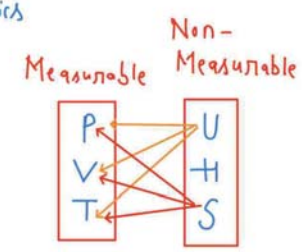
1. Basic Concepts ← Zeroth Law of Thermodynamics, Temperature Measurement
2. Work Interactions
3. First Law of Thermodynamics
4. Heat Interactions

⇒ CLOSED SYSTEM

5. Open System Analysis

⇒ OPEN SYSTEM

6. Second Law of Thermodynamics
7. Entropy
8. Exergy
9. Thermodynamic Relations
10. Properties of Pure Substances

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2. FUNDAMENTALS OF THERMODYNAMICS, SI VERSION : BORGNAKKE & SONNTAG (WILEY)
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4. ENGINEERING THERMODYNAMICS : P K Nag (McGraw Hill) PRACTICE


## CONTENT

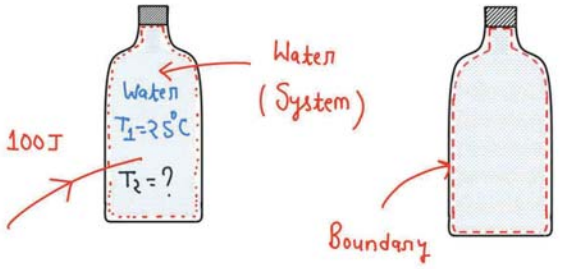
1. Basic concepts
2. Work interactions
3. First law of thermodynamics
4. Heat interactions
5. Open system analysis

## CONTENT

6. Second law of thermodynamics
7. Entropy
8. Exergy
9. Thermodynamic relations
10. Properties of Pure substance

# Basic Concepts

## System, Surrounding & Boundary



Mathematically

Boundary ⟶ Interface

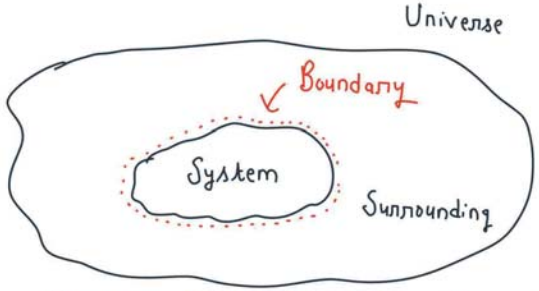
Thickness ⟶ 0

Volume ⟶ 0

mass ⟶ 0

Universe

Universe = System + Surrounding




Universe = System + ~~Boundary~~ + Surrounding

System

- Quantity of Matter
- Region in Space

Surrounding

- Anything external to the system

Boundary

- Interface Shared by System & Surrounding

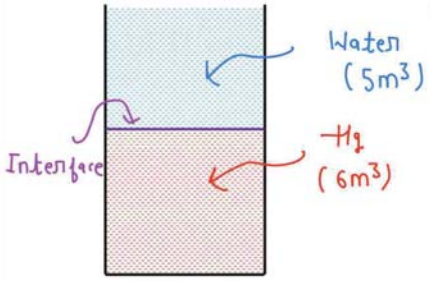
System: Quantity of matter or region in space which is under investigation is known as system

Surrounding: Anything which is external to the system is known as surrounding.

Boundary: Boundary is the interface shared by system and surrounding.

Mathematically, thickness of boundary is zero, hence it has neither volume nor mass.

Universe = System + Surroundings



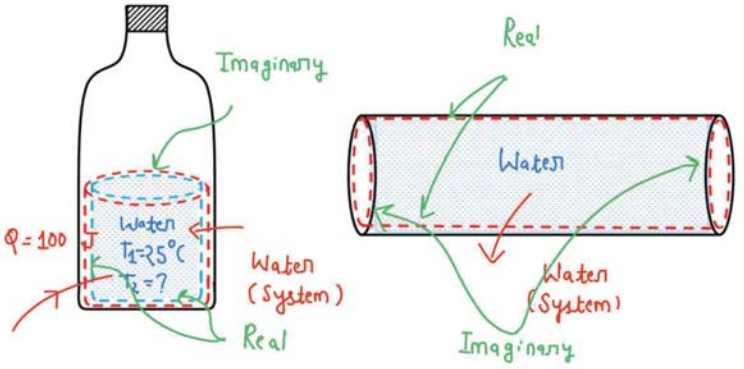

Mercury ($Hg$)

Water ($H_2O$)

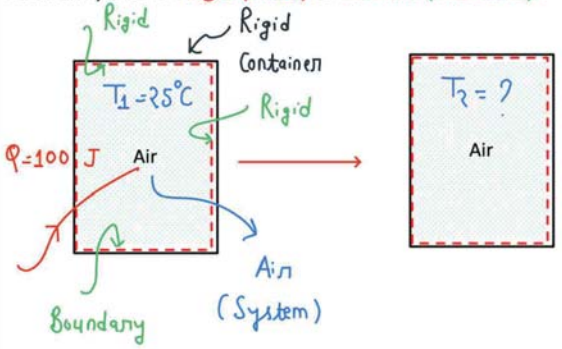
Total Volume (V) =

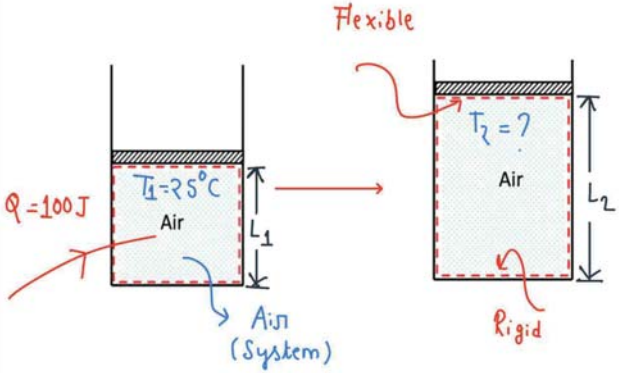
$6m^3 + 5m^3 = 11m^3$

Boundary can be real or imaginary.



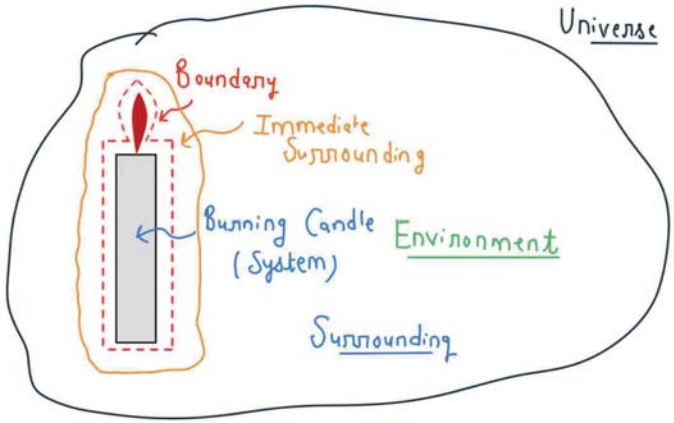
Boundary can be rigid (fixed) or flexible (movable).

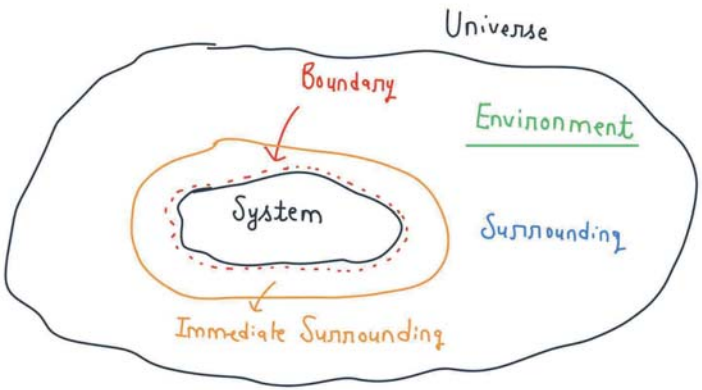



**INTERVIEW QUESTION**

What is the difference between surrounding and environment ?



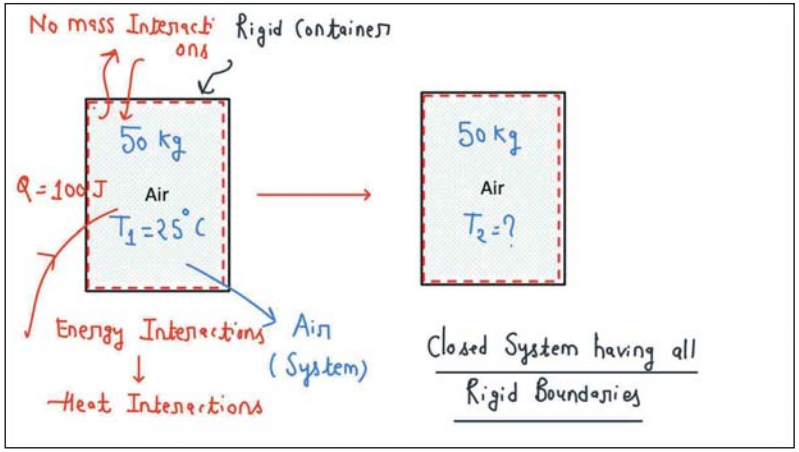

Surrounding = Immediate Surrounding + Environment

↓ Intensive Properties changes

↓ No Effect

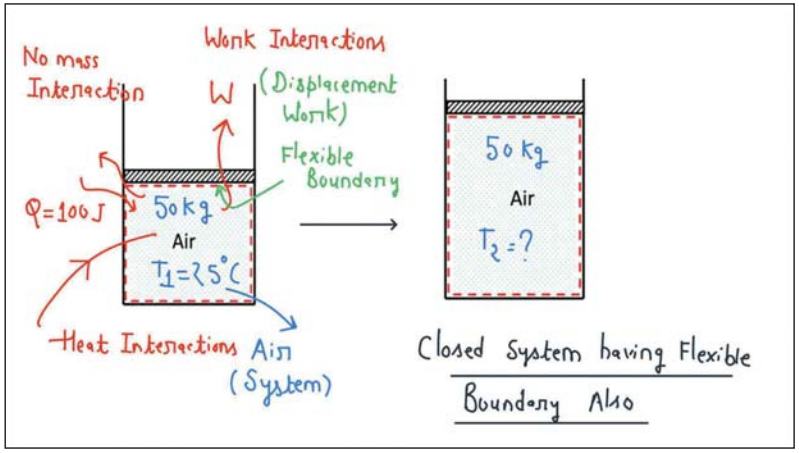
Universe = System + Immediate Surrounding + Environment

- The part of the surrounding where intensive properties can vary during energy interactions is known as immediate surrounding. Where as remaining part of surrounding where intensive properties are unaffected during energy interactions is known as environment.




## Types of System

1. Closed System
2. Isolated System
3. Open system




## Closed System

Mass interactions ✗

Energy interactions ✓

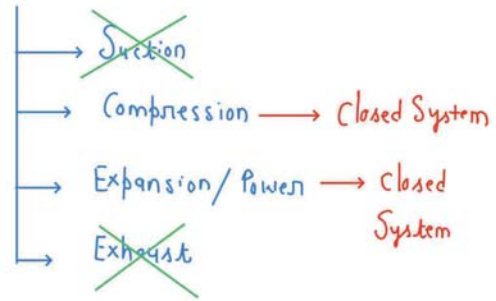
→ Heat Interactions

→ Work Interactions

* No mass interaction

Closed System ⟶ Control mass

4 Stroke IC Engine

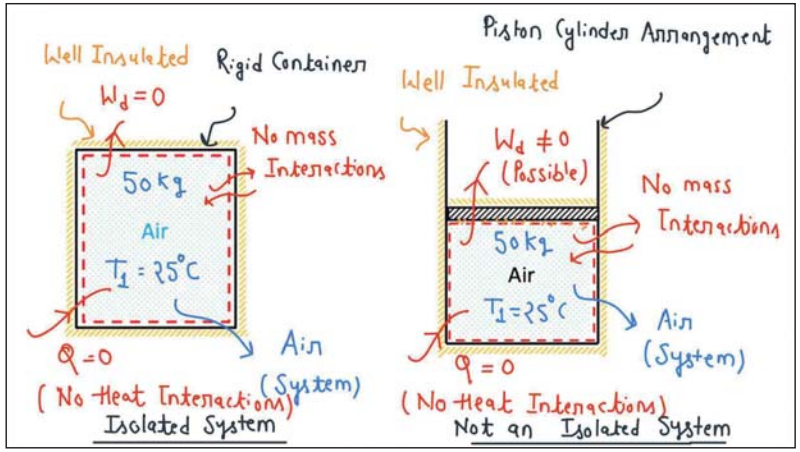



- Closed system is the system in which mass interactions can't take place but energy interactions can take place.
- For closed system having all rigid or fixed boundaries, displacement work ( $W_d$ ) is zero.
- The term Control mass is sometimes used in place of Closed System.
- The compression and expansion ( power) strokes of a 4 stroke Internal Combustion engine represents closed system.

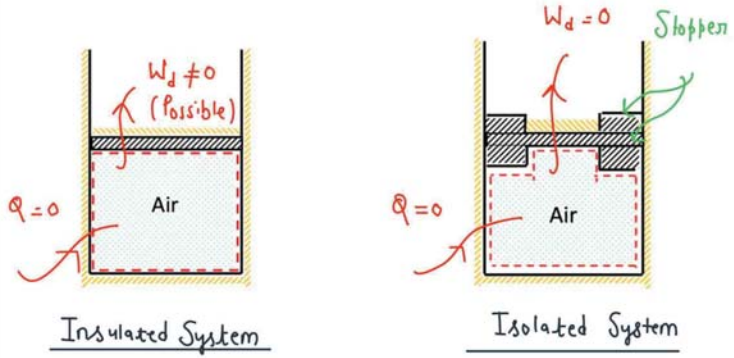
## Isolated System

mass interactions X

energy interactions X

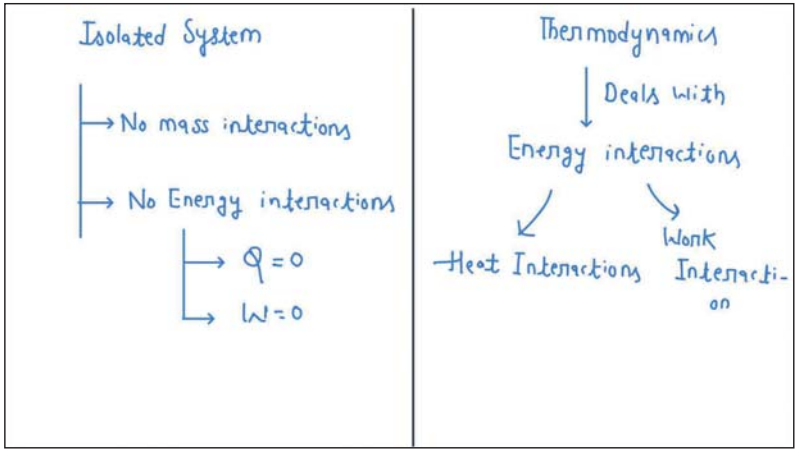


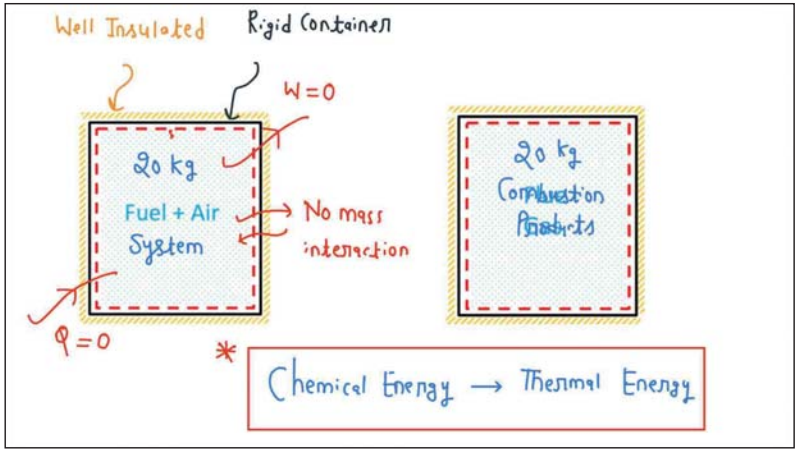

## Isolated System vs Insulated System

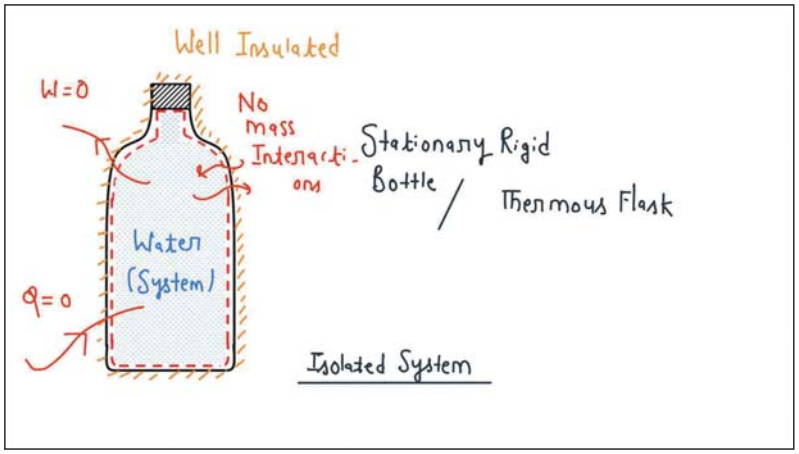


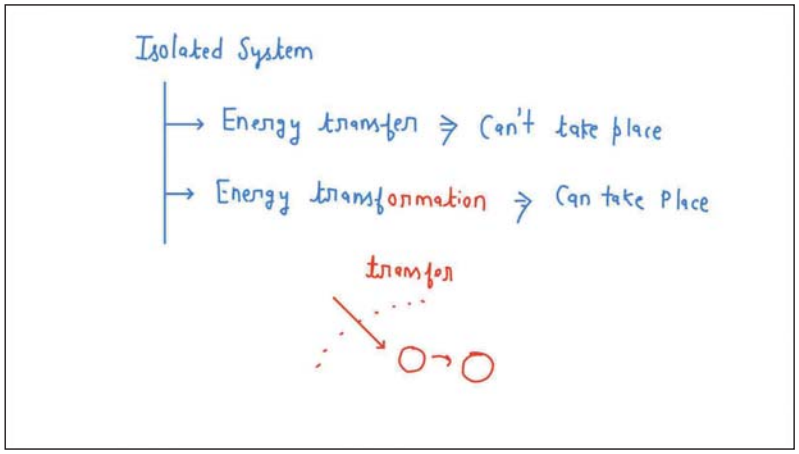

* Insulated System ⟶ $Q = 0$

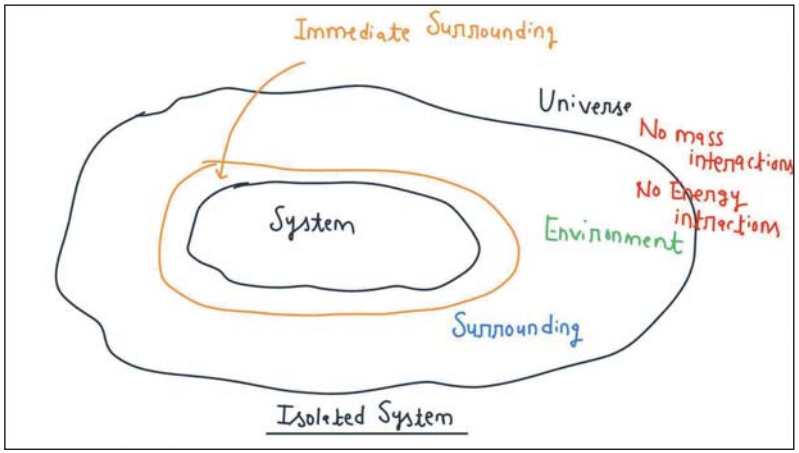
Isolated System ⟶ $Q = 0, W = 0$




- Isolated system is the system in which neither mass nor energy interactions can take place.
- For insulated system heat interactions is zero but work interactions can take place.
- Since thermodynamics deals with energy interactions and in isolated system there is no energy interactions, hence we don't study isolated system in detail.
- In isolated systems, energy transfer can't take place, but energy transformation can take place.

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# BASIC THERMODYNAMICS
## DPP - 1

1. A closed thermodynamic system is one in Which
A. there is no energy or mass transfer across the boundary
B. there is no mass transfer, but energy transfer may exist
C. there is no energy transfer, but mass transfer may exist
D. both energy and mass transfer take place across the boundary, but the mass transfer is controlled by valves.

**Answer: B**

**2. Assertion (A):** A thermodynamic system may be considered as a quantity of working substance with which interactions of heat and work are studied.
**Reason (R):** Energy in the form of work and heat and mutually convertible.
A. Both A and R are true and R is a correct explanation of A.
B. Both A and R are true but R is not a correct explanation of A.
C. A is true but R is false.
D. A is false but R is True.

**Answer: B**

3. A closed thermodynamic system manifests
when
A. Matter is not allowed to cross the boundary, but energy transfer can occur across the boundary
B. There can be transfer of both mass and energy across the system boundaries
C. There can be only transfer of mass, but no heat and work energy are transferred
D. There is absolutely no interaction of the system with surroundings.

**Answer: A**

4. A thermodynamic system is considered to be an isolated one if
A. mass transfer and entropy change are zero
B. entropy change and energy transfer are zero
C. energy transfer and mass transfer are zero
D. mass transfer and volume change are zero

**Answer: C**

5. A closed system is one in which
A. mass does not cross boundaries of the system, though energy may do so
B. mass can cross the boundary but not the energy
C. neither mass nor energy can cross the boundary of the system
D. both energy and mass can cross the boundaries of the system

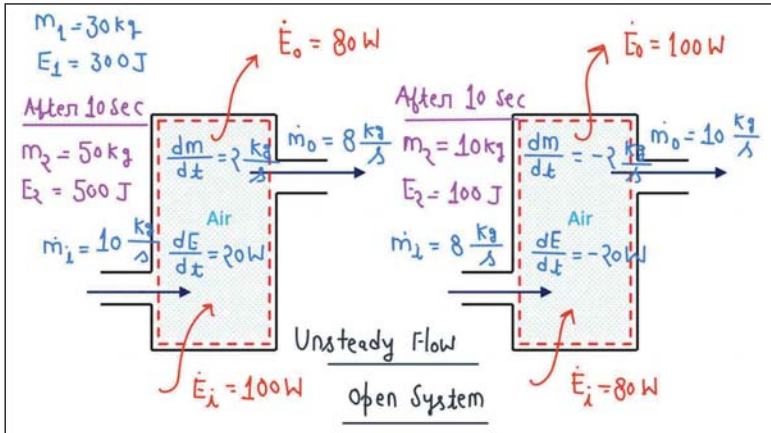
**Answer: A**

## Open System

mass interactions ✓

energy interactions ✓

Distinction should be made between the *surroundings*, *immediate surroundings*, and the *environment*. By definition, **surroundings** are everything outside the system boundaries. The **immediate surroundings** refer to the portion of the surroundings that is affected by the process, and **environment** refers to the region beyond the immediate surroundings whose properties are not affected by the process at any point. Therefore, any irreversibilities




# Basic Concepts - Part II

Complete Course on Basic Thermodynamics for ME/XE/CH/PI (H)

Devendra Singh Negi · Lesson 2 · Mar 3, 2022