

# **Chemical Engineering (Thermodynamics I) (UCH305)**



**Thapar Institute of Engineering & Technology  
(Deemed to be University)**  
Bhadson Road, Patiala, Punjab, Pin-147004  
Contact No. : +91-175-2393201  
Email : info@thapar.edu

**Dr. Neetu Singh  
Associate Professor  
Department of Chemical Engineering**



**THAPAR INSTITUTE  
OF ENGINEERING & TECHNOLOGY  
(Deemed to be University)**

# Lecture 16

## Second Law of Thermodynamics

# Outline

- Statements of the Second Law
- Heat engines
- Refrigeration devices
- Heat pump

## The second law of thermodynamics

The second law of thermodynamics states that processes occur in a certain direction, not in the reverse direction. Physical processes in nature can proceed toward equilibrium spontaneously:

- Water flows down a waterfall.
- Gases expand from a high pressure to a low pressure.
- Heat flows from a high temperature to a low temperature.

## Example 1– Hot Coffee

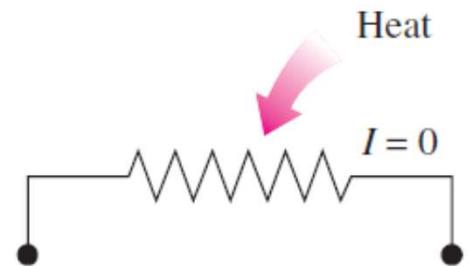
- A cup of hot coffee left in a room eventually cools off.
- This process satisfies the first law of thermodynamics since the amount of energy lost by the coffee is equal to the amount gained by the surrounding air.
- Now let us consider the reverse process –
  - the hot coffee getting even hotter in a room as a result of heat transfer from the room air.
- We all know that this process never takes place.



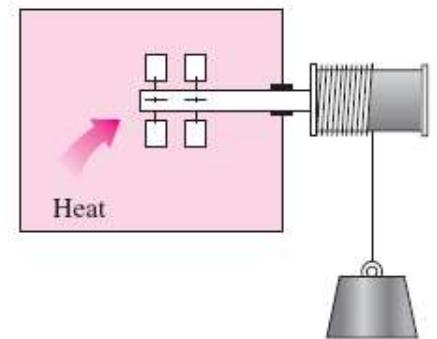
A cup of hot coffee does not get hotter in a cooler room

## Example 2 – Electrical Heater

- Consider the heating of a room by the passage of electric current through a resistance wires.
- Again, the first law dictates that the amount of electric energy supplied to the resistance wires be equal to the amount of energy transferred to the room air as heat.
- Now let us attempt to reverse this process. But transferring some heat to the wires does not give an equivalent amount of electric energy to be generated in the wires.



Transferring heat to a wire will not generate electricity



Transferring heat to a paddle wheel will not cause it to rotate.

## Example 3-Paddle wheel

- It is clear from these discussions that processes occur in a *certain direction* and not in the **reverse** direction.
- The first law places no restriction on the **direction** of a process, but satisfying the first law ***does not ensure*** that the process can actually occur.
- This **inadequacy** of the **first law** to identify whether a process can take place is remedied by introducing another **general principle**, the ***second law of thermodynamics***.
- A process cannot occur unless it **satisfies** both the **first-law** and the **second-law** of thermodynamics.

## The second law of Thermodynamics

- The use of the second law of thermodynamics is not limited to identifying the direction of processes.
- The second law also asserts that energy has *quality* as well as quantity.
- The first law is concerned with the quantity of energy and the transformations of energy from *one form to another form* with no regard to its quality.
- Preserving the quality of energy is a major concern to engineers.
- The second law provides the necessary means to determine the quality as well as the degree of degradation of energy during a process.

## Second law of thermodynamics

- The *second law of thermodynamics* is also used in determining the *theoretical limits* for the performance of commonly used engineering systems, such as:
  - Heat engines,
  - Refrigerators,
  - Heat pumps, as well as
    - \* predicting the *degree of completion* of chemical reactions.

## Heat engines





Diesel



Petrol



## Refrigerator

- The process is used to cool the items in Refrigerator in summer season.



## Heat pump



- The process is opposite to the Refrigerator.
- The process is used to heat the room in cold climate.

## References

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*Thank you for your  
Patience*