

# UCH305 Chemical Engineering Thermodynamics I



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

# Chemical Engineering (Thermodynamics I) (UCH305)



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# UCH305 Chemical Engineering Thermodynamics I

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## Course Objective

To understand the laws of thermodynamics, availability, the concept of entropy change, entropy generation and thermodynamic cycles as applied to a variety of engineering systems.

## **Course Learning Outcomes (CLO):**

Upon completion of this course, the students will be able to:

1. Estimate properties of pure substance using steam tables, property diagrams and equation of states.
2. Analyze and solve problems involving closed system and open systems for both steady state and transient processes.
3. Analyze the second law of thermodynamics for various systems and to evaluate the performance of heat engines, refrigerators and heat pumps.
4. Analyze the performance of various power cycles and to identify methods for improving thermodynamic performance.
5. Analyze and solve problems involving non-reacting gas mixtures.

# Books

## Text Books

1. Rao, Y.V.C., *Chemical Engineering Thermodynamics*, Universities Press (2009).
2. Smith J. M. and Van Ness H. C., *Chemical Engineering Thermodynamics*, Tata McGraw-Hill (2007) 6<sup>th</sup> ed.
3. Nag, P.K., *Engineering Thermodynamics*, Tata McGraw Hill (2008) 3<sup>rd</sup> ed.

## Reference Books

1. Cengel, Y. A. and Boles, M., *Thermodynamics: An Engineering Approach*, Tata McGraw Hill (2008).
2. RathaKrishana , E., *Fundamentals of Engineering Thermodynamics*, Prentice Hall of India (2005) 2<sup>nd</sup> ed.
3. Sonntag, R.E., Borgnakke, C. and Van Wylen, G.J., *Fundamentals of Thermodynamics*, John Wiley (2007) 6<sup>th</sup> ed.
4. Rogers, G. and Mayhew, Y., *Engineering Thermodynamics*, Pearson Education (2007) 4<sup>th</sup> ed.

## Evaluation scheme

S. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessional (may be tutorials/quizzes/assignments/project)	25

## Syllabus – UCH305

- **Introduction and Basic Concepts:** Role of thermodynamics in engineering and science, Applications of Thermodynamics, Concept of Continuum, Macroscopic approach, Thermodynamics system and properties, Various processes, Thermodynamic equilibrium, Ideal gas, Vander Waals equation of state, Compressibility chart, Process: Flow and non flow process, Cycle concept of work and heat, Specific heats, Zeroth law, Energy and its form, Pure substance, Thermodynamic diagrams, Triple point, Steam tables and their use.
- **First Law of Thermodynamics:** Concept of internal energy & enthalpy, Energy equation as applied to a close and open system, PMMI, Transient flow processes.
- **Second Law of Thermodynamics & its Corollaries:** Kelvin Plank and Clausius statements, Reversible and Irreversible processes, Carnot cycle, Clausius theorem and concept of entropy, Principle of increase of entropy, PMM2, Thermodynamic temperature scale, Second law analysis of control volume, Availability, Irreversibility, Availability function for open and closed system & second law efficiency.
- **Thermodynamic Cycles:** Rankine cycle, Vapour compression refrigeration cycle, Air standard cycles: Otto, Diesel, Dual and Brayton cycles.
- **Non-Reacting Gas Mixtures:** Properties of mixtures of gases and vapours, Adiabatic saturation, Properties of air.

# **Lecture 1**

## **Introduction and Basic Concepts**

## **Outline**

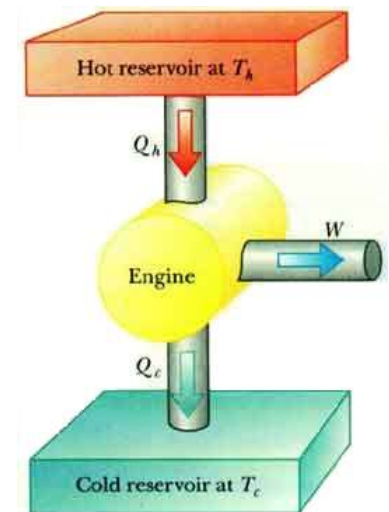
- What is thermodynamics?
- Role of thermodynamics in engineering and science
- Applications of Thermodynamics
- Macroscopic and microscopic approaches

# What is Thermodynamics?

- Thermodynamics can be defined as the science of energy.
- The name thermodynamics stems from the two Greek words  
“*therme*” (heat) + *dynamis* (power)

which is most descriptive of the early efforts to convert heat into power.

- Today the same name is broadly interpreted to include all aspects of energy and energy transformations, including:
  - power generation
  - refrigeration, and
  - relationships among the properties of matter.



## **Role of thermodynamics in engineering and science**

1. All physical processes observed in universe follow the laws of thermodynamics.
2. Thermodynamics plays an important role in general science and engineering.

# Applications of Thermodynamics

## General application areas:

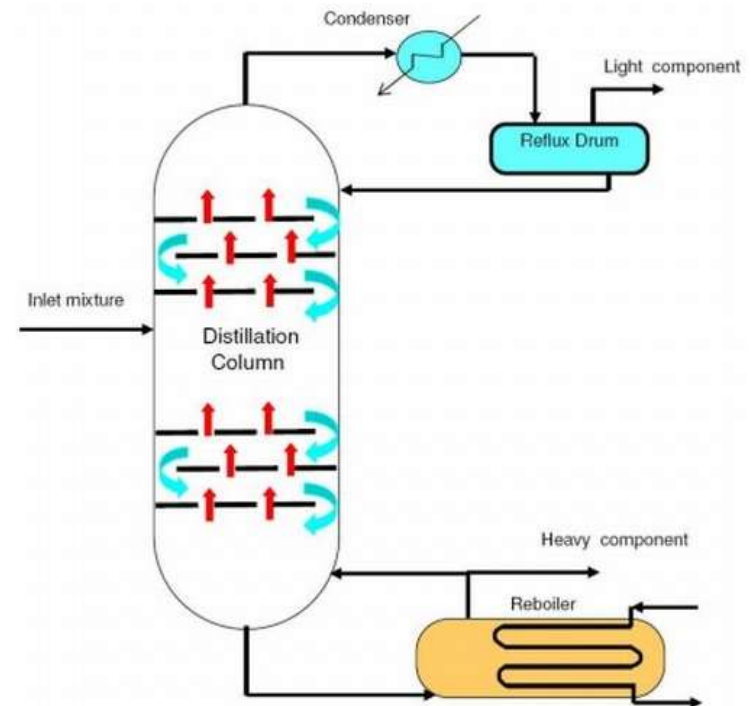
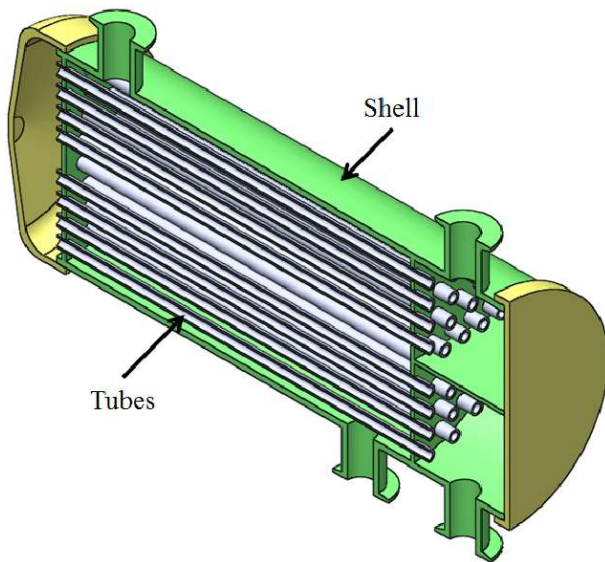
- Our body
- Household utensils & Household appliances  
(*pressure Cooker, refrigerator, humidifier, water heater, shower, iron, computer and TV*).
- automotive engines, rockets, jet engines, and conventional or nuclear power plants, solar collectors, and the design of vehicles from ordinary cars to airplanes



# Applications of Thermodynamics ....

## Chemical engineering applications

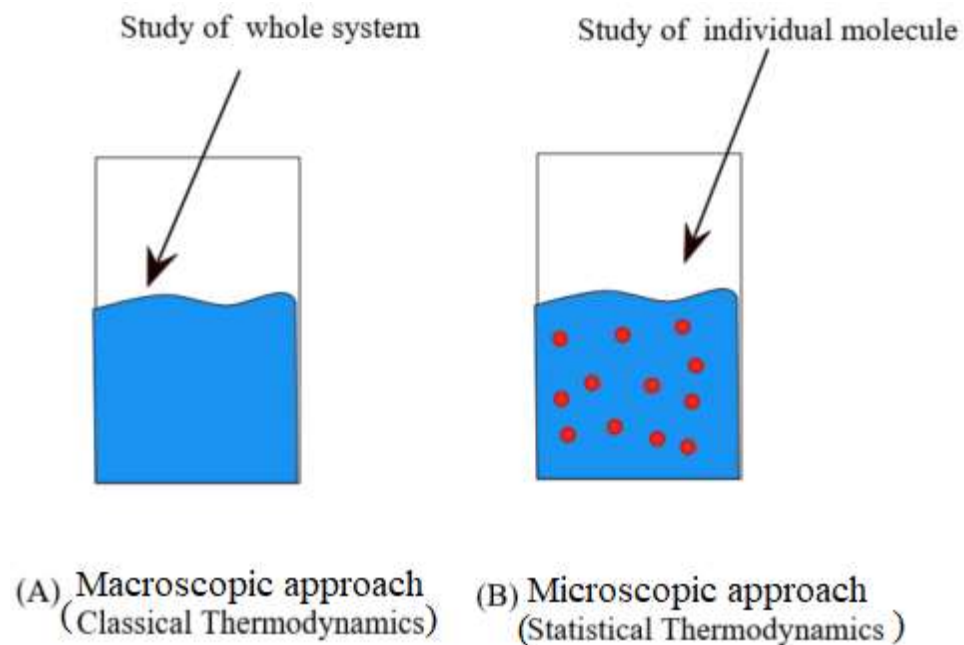
- Phase & reaction equilibria
- Separation processes
- Design of equipment in equilibrium processes



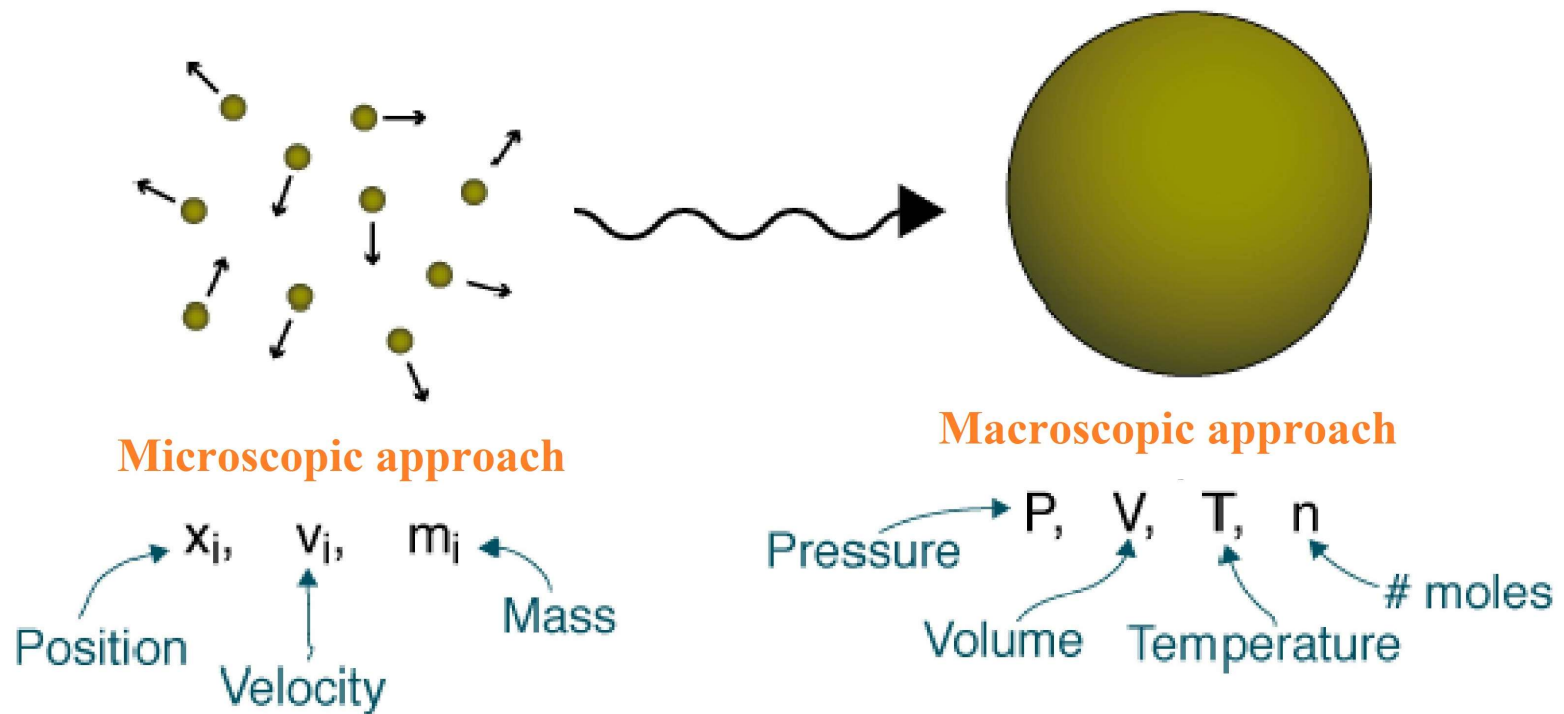
# Macroscopic and microscopic approaches of Thermodynamics

Thermodynamics can be studied by adopting two different approaches:

1. Macroscopic approach- Adopted in *classical thermodynamics*.
2. Microscopic approach- Adopted in *statistical thermodynamics*.



## Macroscopic and microscopic approaches



# Macroscopic and microscopic approaches of Thermodynamics

Thermodynamics can be studied by adopting two different approaches:

## 1. Macroscopic approach (*classical thermodynamics*)

- In this approach, a certain quantity of matter is considered, without taking into account the events occurring at the molecular level.
- This approach of study does not require knowledge of the behaviour of individual particles.

## 2. Microscopic approach (*statistical thermodynamics*)

- From the microscopic viewpoint, matter is composed of a large number of small molecules and atoms.
- The microscopic observations are completely dependent on the assumptions regarding the nature of matter.

## Macroscopic and microscopic approaches....

Macroscopic approach-	Microscopic approach
Only a small no. of variables are used to describe the state of matter.	A large no. of variables are needed to specify the state of matter.
These variables can be measured or estimated.	These variables can not be measured.
The structure of matter under consideration is not taken into account.	A knowledge of the structure of matter is essential to analyse the behaviour of constituent atoms/molecules.

## References

1. *Rao, Y.V.C., Thermodynamics, Universities Press (2004).*
2. *Smith J. M. and Van Ness H. C., Chemical Engineering Thermodynamics, Tata McGraw-Hill (2007).*
3. *Nag, P.K., Engineering Thermodynamics, Tata McGraw Hill (2008) 3rd ed.*
4. *Cengel, Y. A. and Boles, M., Thermodynamics: An Engineering Approach, Tata McGraw Hill (2008).*

*Thank you for your  
Patience*