Thermodynamics

Introduction

Thermodynamics is the branch of physics that studies the relationship between **heat, work, temperature, and energy**. It explains how energy is transferred and transformed in physical systems. Thermodynamics is widely used in engines, refrigerators, air conditioners, power plants, and many industrial processes.

Thermodynamic System

Definition

A **thermodynamic system** is a part of the universe chosen for study, while everything outside it is called the **surroundings**.

Types of systems:

- **Open System** – Exchanges both matter and energy.
- **Closed System** – Exchanges only energy, not matter.
- **Isolated System** – Exchanges neither matter nor energy.

Thermodynamic Variables

State Variables

The condition of a thermodynamic system is described by **state variables**, such as:

- Pressure (P)
- Volume (V)
- Temperature (T)
- Internal Energy (U)

These variables define the state of a system.

Thermodynamic Processes

Types of Processes

Common thermodynamic processes are:

- **Isothermal Process** – Temperature remains constant.
- **Adiabatic Process** – No heat is exchanged.
- **Isochoric Process** – Volume remains constant.
- **Isobaric Process** – Pressure remains constant.

Each process follows different physical conditions.

Internal Energy

Definition

Internal Energy (U) is the total energy possessed by the molecules of a system due to their motion and interactions.

For an ideal gas, internal energy depends only on **temperature**.

Work Done

Meaning

When a gas expands or contracts, it performs **work**.

For constant pressure:

Work Done (W) = P × ΔV

where:

- **P** = Pressure
- **ΔV** = Change in Volume

Work is positive during expansion and negative during compression.

First Law of Thermodynamics

Statement

The **First Law of Thermodynamics** is based on the **law of conservation of energy**.

It states that:

Heat Supplied = Increase in Internal Energy + Work Done

Mathematical form:

ΔQ = ΔU + ΔW

This law shows that energy can neither be created nor destroyed.

Second Law of Thermodynamics

Statement

The **Second Law of Thermodynamics** states that heat **cannot flow naturally from a colder body to a hotter body** without external work.

It also explains the direction of heat flow and the limitations of heat engines.

Heat Engine and Refrigerator

Applications

A **Heat Engine** converts heat energy into mechanical work.

A **Refrigerator** transfers heat from a low-temperature region to a high-temperature region using external work.

These devices operate according to the laws of thermodynamics.

Applications of Thermodynamics

Importance

Thermodynamics is used in:

- Heat Engines
- Refrigerators
- Air Conditioners
- Power Plants
- Automobiles
- Chemical Industries
- Space Technology

It helps improve the efficiency of energy conversion systems.

Key Points

- Thermodynamics studies heat, work, and energy.
- Systems may be open, closed, or isolated.
- Internal energy depends on the state of the system.
- The First Law is based on conservation of energy.
- The Second Law explains the direction of heat flow.
- Heat engines convert heat into work.
- Refrigerators use work to transfer heat from cold to hot regions.

Chapter Summary

This chapter introduces the basic concepts of thermodynamics, including thermodynamic systems, state variables, internal energy, work, and different thermodynamic processes. It explains the First and Second Laws of Thermodynamics and discusses the working of heat engines and refrigerators. These concepts are essential for understanding energy transfer and its applications in science and engineering.