Chapter 17

Temperature and Heat

17.1 Thermodynamics Terminology and Fundamentals

- **System**: A collection of objects.

    - We will focus on systems comprised of gas molecules.

- **Internal energy**: The energy (of such a system) associated with the microscopic motion of the molecules. *Denoted by* $\boldsymbol{E}_{\text{int}}$.

- Systems of molecules conserve momentum within themselves, like any system, but they can also interact with the rest of the world by exchanging energy.

- **Heat**: Energy exchanged between hot and cold systems. *Denoted by* $\boldsymbol{Q}$.

- **Temperature**: A measure of E_{int}. *Denoted by* $\boldsymbol{T}$.

- Heat flows from a hot system to a cold system until thermal equilibrium is reached.

    - Thermal equilibrium implies equal temperatures.

- **Zeroth Law of Thermodynamics**: If $T_A = T_B$ and $T_B = T_C$, then $T_A = T_C$.

    - You can think of B as a thermometer — if it reads the same for two different systems, those systems have the same temperature.

- To measure temperature, we need a thermometric property.

    - One example of a thermometric property is the dependence of the volume of mercury on temperature.
        - Celsius stuck a column of mercury in ice water and called it 0°. Similarly, he called a column of mercury in hot steam 100°.
        - Fahrenheit used iced brine (salt water) for 0° and sheep's blood for 100°.
    - Alternatively, we could measure the **pressure** of a gas, for instance.

- **Pressure**: The quotient of force and area. *Units* Pa.

    - $1\,\text{Pa} = 1\,\text{N/m}^2$.
    - $1\,\text{atm} = 1.01 \times 10^5\,\text{Pa} \approx 14\,\text{lb/in}^2$.

- **Absolute temperature**: The temperature defined by

$$T = 273 \cdot \frac{P}{P_{1\,\text{atm}}}$$

where P is the pressure of a gas at temperature T.

- **Absolute zero**: The temperature when the pressure of a gas is 0.

- Note that

$$T_C = T - 273° \qquad\qquad\qquad T_F = \frac{9}{5}T_C + 32$$

- Equations of motion relate kinematic quantities, such as time, position, velocity, and acceleration.

- Equations of state relate thermodynamic properties of a system, such as pressure, volume, temperature, and moles.