
Week 8

Lecture 1

• Zeroth Law of Thermodynamics.
• Temperature scales:
• Fahrenheit: $^\circ F$, Celsius: $^\circ C$
• Absolute temperatures: Rankine: R, and Kelvin: K
• See Website for relationships and conversions between the various temperature scales.
• Boiling point of water and the triple point of ice, water and its vapor for the various temperature scales.

• Perfect gas law (equation of state): $PV = MRT$ where P = pressure, V = volume, M = mass, T = temperature, and R = gas constant
• See Website for values of gas constant for different gases.

• Types of processes:
• Isothermal process: T = constant temperature
• Isobaric process: P = constant pressure
• Isochoric process: V = constant volume
• Adiabatic process: no heat transfer $Q = 0$
• Polytropic process: $P\,V^n = C, \quad 0 < n < \infty$
• Quasistatic process: consists of succession of equilibrium states
• Reversible process: initial state of the system can be restored
• Irreversible process: initial state of the system cannot be restored without observable effects in the system and its surroundings.

• Sign convention: heat and work into a fixed mass system are considered to be positive because they increase the internal energy of the system $\Delta U > 0$.

Lecture 2

• Midterm exam. Today: 4:30-6:30 PM

• Piston-cylinder system with gas, or liquid, or a mixture of a liquid and its vapor.
• Assume a perfect gas occupies the space defined by the frictionless piston and the cylinder.
• Define work: $W_{12} = \int_{x_1}^{x_2} F dx = -\int_{V_1}^{V_2} P dV$ where $P = F/A$ and $dV = Adx$, and A is the cross-section of the piston. The negative sign is consistent with the sign convention.
• Cycle consisting of three processes: state 1 to state 2 is isobaric process, state 2 to state 3 is isochoric process, and state 3 to state 4 is isothermal process. State 4 is equal to state 1.
• Show the cycle on a $P-V$ diagram. Label the end points and the processes.
• Find the work done during each process and the cycle:
$W_{14} = W_{12} + W_{23} + W_{34}$ where $W_{12} = -\int_{V_1}^{V_2} P dV = -P_1(V_2 - V_1)$, $W_{23} = -\int_{V_2}^{V_3} P dV = 0$ because $dV = 0$, $W_{34} = -\int_{V_3}^{V_4} P dV = -C\int_{V_3}^{V_4} dV/V = -C\ln(V_4/V_3) = C\ln(V_3/V_4)$, because for an isothermal process we have $PV = MRT$ with $T =$ constant. Since $T_3 = T_4 = T_1$ and $V_4 = V_1$, $W_{34} = MRT_1 \ln(V_3/V_1)$.

Lecture 3

• Closed cycle: $\Delta U = 0$, therefore $\Delta Q = \Delta W$ for the cycle provided $\Delta PE = 0$, $\Delta KE = 0$. Other examples of work.
