ChBE 2130 Thermodynamics I (required course)

Credit: 2-0-2

Instructor: Dr. Martha Grover

Textbook: J. M. Smith, H. C. Van Ness, and M. M. Abbott, "Introduction to Chemical Engineering Thermodynamics," Seventh Edition, Prentice Hall, 2005.

Catalog Description: Thermodynamic laws and their applications in ideal gas and real fluids are the key parts of the course, which are discussed in details in this course.

Prerequisites: Chemical Process Principles (ChBE 2100) with a minimum grade of "c", Biological Principles (Biol 1510) is a co-requisite.

Objectives: First and second thermodynamic laws and analyses of problems using these laws in open, closed, and isolated systems. Thermodynamic relationships among thermodynamic properties (energy, heat, work, enthalpy, entropy, free energy, fugacity, temperature, pressure, volume, etc.) Analyze typical thermodynamic devices and units (turbine, pump, nozzles, compressor, heat pump, refrigerator, etc.) using thermodynamic principles

Learning outcomes: By the end of this course, a student should be able to:

1. Extend the systems analysis method to define complex thermodynamic systems including transient materials and energy balances for open and closed systems.
   (Student Outcomes: a, c, k)

2. Be able to correctly use the First Law of Thermodynamics to find heat, work, and changes in internal energy and enthalpy for the analysis of any system, open or closed, undergoing irreversible processes. (Student Outcomes: a, c, k)

3. Apply the Second Law of Thermodynamics and the concept of entropy production to the analysis of reversible and real systems. (Student Outcomes: a, c, e, k)

4. Use equations of state for gases and liquids to determine changes in PVT properties. Understand the molecular concepts. (Student Outcomes: a, c, k)

5. Understand the relationships among the interval energy, enthalpy, heat capacities, entropy, Gibbs and Helmholtz free energies. Be able to calculate these energy functions from equations of state and heat capacity data. (Student Outcomes: a, c, e, k)

6. Perform thermodynamic analysis of Carnot, Rankine, Brayton, Otto, and Diesel cycles and be able to calculate ideal efficiencies for these cycles. (Student Outcomes: a, c, e, k)

7. Design and analyze refrigeration cycles and gas liquefaction processes. (Student Outcomes: a, c, e, k)

Topical Outline

1. First Law: Energy balance in open, closed, and isolated systems; steady state and transient processes
2. Second Law: reversible and irreversible processes; entropy balance for open, closed, and isolated systems
3. Third Law: molecular basis for zero entropy at zero temperature
4. Properties of pure fluids: phase diagrams, equations of state, compressibility factor, generalized correlations, residual properties, equations of state for liquids
5. Ideal gas and real fluids: cubic equations; departure functions
6. Relationship among thermodynamic functions: fundamental relationships between thermodynamic properties; Maxwell equations; thermodynamic property calculations
7. Thermodynamics of fluid flow and devices: expansion and compression of fluids; turbines, tubes, throttling, nozzles, pumps
8. Supersonic flow of ideal gases
9. Thermodynamics of energy conversion: power production (e.g. Carnot cycle; Rankine cycle, internal combustion engine; Diesel engine)
10. Refrigeration and liquefaction: Carnot and actual cycles; vapor compression and absorption; refrigerants; liquefaction of gases

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