**CHEN 2110 – CHEMICAL ENGINEERING THERMODYNAMICS (3)**

**Required Core Course**

**2020-2021 Catalog Data Lec (3)** This course is intended to comprehensively introduce the thermodynamics of single- and multi-phase, pure systems, including the first and second laws of thermodynamics, equations of state, simple processes and cycles, and their applications in chemical engineering.

**Prerequisites** CHEM 1030 or CHEM 1033 or CHEM 1110 or CHEM 1117, and MATH 1620 or MATH 1623 or MATH 1627, and CHEN 2100, and P/C PHYS 1600 or PHYS 1607, and P/C CHEN 2650, and CHEN 2100 requires a grade of C or better.

**Schedule** Two seventy-five minute class sessions per week

**Course Objectives** This course introduces the thermodynamics of single- and multi-phase, pure systems, including the first and second laws of thermodynamics, equations of state, simple processes and cycles, and their applications in chemical engineering.

**Textbooks**

Dahm and Visco, Fundamentals of Chemical Engineering Thermodynamics, 1e, 2014, 978-1111580704, Cengage Learning

**Topics Covered**

1. Concepts and definitions (1 weeks)
2. Physical properties of pure compounds (2 weeks)
3. First Law of Thermodynamics (1 week)
4. Material and Energy Balances (1 week)
5. Reversible processes, entropy and the Second Law of Thermodynamics (3 weeks)
6. Real heat engines, refrigeration, and liquefaction processes (2 weeks)
7. Multivariable calculus and residual properties (2 weeks)
8. Equations of State (2 weeks)
9. Exams (1 week)

**Course Outcomes:**

1. Explain the concepts of heat, work, kinetic energy, potential energy, internal energy (U), enthalpy (H), entropy (S), Helmholtz energy (A), and Gibbs free energy (G).
2. Explain the concepts of closed and open systems, intensive and extensive properties, thermodynamic state, process path, state and path functions, reference state and heat capacity at constant pressure (Cp) and volume (Cv), volume expansivity, and isothermal compressibility.
3. Explain the concepts of reversible and irreversible processes.
4. Explain the first and second laws of thermodynamics.
5. Explain the molecular basis for thermodynamics.
6. Apply the first and second laws of thermodynamics to solve closed-system engineering problems.
7. Apply the first and second laws of thermodynamics to solve open-system engineering problems.
8. Use thermodynamic tables, charts, and equations of state, including the ideal gas law; van der Waals equation; virial equation; generalized cubic equations of state; generalized correlations; and steam tables, to approximate the thermodynamic properties (e.g. density, temperature, pressure, specific volume, internal energy, etc.) for pure substances.
9. Draw a process path on P-T, P-V, T-V, H-P and T-S diagrams as an aid to solving thermodynamic problems.
10. Describe and analyze cyclic processes as related to heat engines, heat pumps, power generation and refrigeration systems.
11. Calculate the efficiency of process equipment such as pumps, compressors, turbines and nozzles.
12. Design and evaluate thermodynamic processes that minimize entropic losses.
13. Use multivariate calculus (partial and total derivatives) to develop general fundamental property relations for differential changes in fundamental thermodynamic properties (U, H, A, G) in a simple closed system.
14. Apply multivariable calculus to derive the Maxwell relations and then develop the “Fundamental Property Equations” to relate easily measured experimental properties (P, V, T) to thermodynamic quantities (dU, dH, dA, dG).
15. Demonstrate the ability to use Fundamental Property Equations, Maxwell relations, and equations of state in conjunction with one another to solve problems involving process changes starting from either P-V-T data or thermodynamic property data.
16. Explain the concept of residual properties and calculate them for practical engineering applications using equations of state, generalized correlations, and thermodynamic tables and charts.

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| **Contribution of Course to Meeting ABET Criteria 5 (Curriculum)** |
| **Math and Basic Sciences** | **Engineering Topics** | **General Education** |
| 0 Credits | 3 Credits | 0 Credits |

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| **Relationship of Course to Program Outcomes (PO’s)** |
| **Program Outcome** | **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| **Level of Coverage** | **S** |  |  |  |  | **I** | **S** |

**Date of Preparation and Person(s) Preparing This Description**December 15, 2021: Allan E. David, Virginia A. Davis, and Robert J. Pantazes