

PHYC 434 Thermodynamics

Course Description

Classical and statistical thermodynamics. Basic concepts, principles, and theories of thermodynamics. Equations of state, laws of thermodynamics, introduction to the kinetic theory of gases, and classical and quantum statistics. (3 credit hours)

Prerequisite: PHYC 330; MATH 267

Course Objectives

The goal of the course is to provide students a basic understanding of the principles of thermodynamics. It provides a solid introduction to the classical and statistical theories of thermodynamics. It deals with temperature, heat, pressure, entropy, and other variables in the physical world. Students learn the laws of thermodynamics and their applications in physical systems and industries. The students find an opportunity for the development of analytical and problem solving skills.

Course Rationale

This course is offered for the third- or fourth-year physics students. It is a one-semester, three hour course. Thermodynamics is one of the fundamental areas in physics and engineering. The central concept of thermodynamics is temperature. In order to understand the macroscopic properties of a system in the physical world, one needs to know the laws physics. The course provides phenomenological theories, describing macroscopic properties of matter, most of which are amenable to direct measurement. Problem solving, critical thinking, analytical skills, and knowledge of their application in real systems, particularly, in the industries, are necessary for the success of any physics student.

Course Content, Format, and Bibliography

Content

The Zeroth Law of Thermodynamics, The definition of temperature scales and thermodynamic equilibrium

Fundamental concepts: Thermodynamic systems, state of a system, Pressure, thermal equilibrium

Equations of state: Equation of state of an ideal gas, P-v-T surface for an ideal gas, Equations of state for real gases, P-V-T surfaces for real substances, equations of state for other than P-V-T systems, expansivity and compressibility and Van der Waals gas.

The First Law of Thermodynamics: The concept of work, definition of the First Law, the concept of internal energy and heat flow, the mechanical equivalent of heat; heat capacity, the concept of enthalpy, and the energy equation of steady flow

Applications and some consequences of the First Law: Various cases for pairs of state variables taken as independent variables, the Gal-Lussac-Joule and the Joule-Thompson experiments, reversible adiabatic processes and the Carnot cycle; the heat engine and the refrigerator.

Entropy and the Second Law of Thermodynamics: Definition of the Second Law, the concept of thermodynamic temperature, definition of entropy, calculations of entropy changes in reversible processes, entropy changes irreversible processes, the principle of increase of entropy, and the Clausius and Kelvin-Planck statements of the Second Law.

Combined First and Second Laws: Various cases for pairs of state variables taken as independent variables, the Tds equations, properties of a pure substance, properties of an ideal gas, properties of a van der Waals gas, properties of a liquid or solid under hydrostatic pressure, and the Joule and Joule-Thomson experiments.

Thermodynamic potentials: The Helmholtz function and the Gibbs function, the concept of thermodynamic potentials, the Maxwell relations, stable and unstable equilibrium, phase transitions, the Clausius-Clapeyron equation, and the Third Law of Thermodynamics

Applications of thermodynamics to simple systems: Chemical potential, phase equilibrium and the phase rule, dependence of vapor pressure on total pressure, surface tension, vapor pressure of a liquid drop, the reversible voltaic cell, thermodynamics of magnetism and engineering applications.

The Kinetic Theory of Gases: Basic assumptions, molecular flux, gas pressure and the ideal gas law, equipartition energy, specific heat capacity of an ideal gas, distribution of molecular speeds, mean free path and collision frequency

Statistical Thermodynamics: Coin tossing experiment, assembly of distinguishable particles, thermodynamic probability and entropy, quantum states and energy levels.

Classical and Quantum Statistics: Boltzmann statistics, the Boltzmann distribution, the Fermi-Dirac distribution, the Bose-Einstein distribution and the connection between classical and statistical thermodynamics.

Function, partition function for a gas, properties of a monatomic ideal gas, and applicability of the Maxwell-Boltzmann Distribution.

The Thermodynamics of Magnetism: Paramagnetism, properties of a spin-1/2 paramagnet, adiabatic demagnetization, and ferromagnetization.

Bose-Einstein Gases: Blackbody radiation, properties of a photon gas, Bose-Einstein condensation, and properties of a boson gas.

Fermi-Dirac Gases: The Fermi energy, free electrons in a metal, and properties of a fermion gas.

The classical Statistical Treatment of an Ideal gas: Thermodynamic properties from the partition

Format

Homework, examinations, assigned readings and report on the literature. The examinations will consist primarily of problem solving.

This course is taught as a dual undergraduate/graduate course. Students will be required to complete activities appropriate for the level of the course in which they are enrolled. Student performance on homework, exams and/or labs will be evaluated using different standards for undergraduate and graduate students.

Bibliography

Schroeder, *Introduction to Thermal Physics*, Pearson (Addison Wesley), ISBN 0-201-38027-7

Classical and Statistical Thermodynamics by Ashley H. Carter, 2001.

Thermal Physics by Ralph Baierlein, 1999

Thermal Physics by Charles Kittel/Herbert Kromer, Second Edition, 1980.