PHY-362 Thermodynamics

Credit Hours: 3-0

Pre-requisite: None

Course Objectives: This course aims to provide students with an introduction to thermodynamics. The course explores how the various thermodynamic quantities, such as pressure, internal energy and temperature are related in different thermodynamic systems. Based on these concepts, understanding of the laws of thermodynamics will be developed.

Core Contents: Temperature, the zeroth law of thermodynamics, Reversible processes and work, the first law of thermodynamics, the second law of thermodynamics, Entropy, thermodynamic potentials and Maxwell relations, Thermodynamic relations, Change of phase, Open systems, chemical potential, the third law of thermodynamics.

Detailed Course Contents: Systems, state variables, thermal equilibrium, the zeroth law of thermodynamics, temperature, thermodynamic equilibrium, isotherms, equation of state, scales of temperature, the gas scale, reversible processes, bulk modulus, work, free expansion, dissipative work, other kinds of work, work in a reversible process, joule's experiments, the first law of thermodynamics and internal energy function, heat, heat capacity, ideal gases, non-ideal gases, joule-kelvin effect, steady flow, Carnot cycles, efficiency of an engine, the second law of thermodynamics, kelvin and Clausius statements, Carnot's theorem and its corollary, the thermodynamic temperature scale, the equivalence of thermodynamic and the ideal gas scales, the efficiencies of engines and refrigerators, real engines, the Clausius inequality, entropy, entropy change in free expansion, the principle of increasing entropy, net entropy change for the universe, the entropy of an ideal gas, probability and disorder, the degradation of energy, thermodynamic potentials, the internal energy, enthalpy, the Helmholtz function, the Gibbs function, the availability function, the Maxwell relations and their use, the difference of the heat capacities, the energy equation, ratio of heat capacities, the joule coefficient for a free expansion, the joule-kelvin coefficient, liquefaction process, magnetic system, magnetic cooling and its thermodynamic analysis, radiation, the radiation pressure, the spectral energy density, cavity radiations, Stefan law, the Kirchoff's law, thermal expansion coefficient, electrolytic cell, phase, the equilibrium condition for two phases, the Clausius-Clapeyron equation, melting point of ice and boiling point of water, vaporization curve, the variation of g, second order phase changes, phase changes of different orders, the Ehrenfest equations, superconductivity and superfluidity, the chemical potential, phase equilibrium, application of the concept of chemical potential, the Nernst heat theorem, the third law, absolute zero.

Course Outcomes: At the end of the course, students will get the knowledge of:

- fundamental laws of thermodynamics
- relationship between heat and work
- important observables such as entropy and free energies
- application of the laws of thermodynamics in modeling of physical systems

Textbook: C. B. P. Finn, Thermal Physics, 2nd ed. CRC Press, Taylor & Francis Group, 1993. (Referred as Finn)

Reference Books:

Daniel V. Shroeder, An introduction to Thermal Physics, Addison-Wesley, 1999.

Weekly Breakdown		
Week	Section	Topics
1	Finn 1.1-1.9	Systems, state variables, thermal equilibrium, the zeroth law of thermodynamics, temperature, thermodynamic equilibrium, Isotherms, equation of state, scales of temperature, the gas scale
2	Finn 2.1-2.6	Reversible processes, bulk modulus, work, free expansion
3	Finn 2.7-2.10, 3.1-3.2	Dissipative work, other kinds of work, work in a reversible process, Joule's experiments, the first law of thermodynamics and internal energy function
4	Finn 3.3-3.9	Heat, heat capacity, ideal gases, non-ideal gases, Joule-Kelvin effect, steady flow
5	Finn 4.1-4.6	Carnot cycles, Efficiency of an engine, the second law of thermodynamics, Kelvin and Clausius statements, Carnot's

		theorem and its corollary
6	Finn 4.7-4.11	The thermodynamic temperature scale, the equivalence of thermodynamic and the ideal gas scales, the efficiencies of engines and refrigerators, Real engines
7	Finn 5.1-5.9	The clausius inequality, entropy, entropy change in free expansion, the principle of increasing entropy, net entropy change for the universe, the entropy of an ideal gas
8	Finn 5.10-5.11, 6.1-6.3	Probability and disorder, the degradation of energy, Thermodynamic potentials, The internal energy, Enthalpy
		Midterm Exam
9	Finn 6.4-6.9	The Helmholtz function, the Gibbs function, the availability function, the Maxwell relations and their use
10	Finn 7.1-7.8	The difference of the heat capacities, the energy equation, ratio of heat capacities, The Joule coefficient for a free expansion, the Joule-Kelvin coefficient, liquefaction process
11	Finn 8.1-8.5	Magnetic system, magnetic cooling and its thermodynamic analysis, Radiation, the radiation pressure
12	Finn 8.6-8.11	The spectral energy density, cavity radiations, Stefan Law, the Kirchoff's law, thermal expansion coefficient, electrolytic cell
13	Finn 9.1-9.5	Phase, PVT surfaces, the equilibrium condition for two phases, The Clausius-Clapeyron equation, melting point of ice and boiling point of water
14	Finn 9.6-9.11	Vaporization curve, the variation of G, second order phase changes, phase changes of different orders, the Ehrenfest equations, superconductivity and superfluidity
15	Finn 10.1-10.3, 11.1-11.5	The chemical potential, phase equilibrium, application of the concept of chemical potential, The Nernst heat theorem, the third law, absolute zero