PHYS 8301: Statistical Physics I

Instructor: Dr. M. Bachmann
Room: Physics Bldg. 309
Email: bachmann@smsyslab.org
Course website: www.smsyslab.org/teaching.html

Topics: The first of two parts of this course covers general theoretical concepts of thermodynamics and classical statistical physics. The macroscopic description of thermal behavior by means of a few state variables such as temperature, pressure, free energy, entropy, etc. is based on the Thermodynamic Laws, whereas its microscopic justification is provided by the statistical analysis of the system's individual degrees of freedom. The course reviews the historic foundation of thermodynamics and introduces probability and ensemble theory for the appropriate treatment of the typically huge number of configurational and kinetic degrees of freedom in a macroscopic system.

References: There is a large number of textbooks about this subject and the course material will not be based on a specific one. Recommendations include: *Theoretical Physics 5: Thermodynamics* and *Theoretical Physics 8: Statistical Physics* by W. Nolting; *Statistical Physics* by L. D. Landau and E. M. Lifshitz; *A Modern Course in Statistical Physics* by L. E. Reichl; *Fundamentals of Statistical and Thermal Physics* by Frederick Reif.

Class: Tuesday and Thursday, 11:10am–12:25pm in room 327

Office Hours: You can contact me at any time.

Exams: Midterm and Final (take-home). The midterm exam will be in early October; the final exam in early December. In both exams, only own hand-written lecture notes taken during class, the material provided online by the instructor, and homework solutions are admitted. An exam that was missed without documented reason is assigned the grade F. If the instructor decides that missing an exam was excusable, an oral make-up exam will be set up online. If you should be unable to take an exam for medical reasons, you must inform me before the exam starts and send me a copy of the original medical visit verification provided by your doctor by end of the exam day.

Homework: There will be graded assignments on a regular basis (typically bi-weekly) with strict deadlines. Late homework will not be accepted. Do not submit homework via email (unless directed otherwise).

Grade: Total Grade = (Homework + Midterm + Final)/3

Grading: [100,85]: A; (85,82.5]: A^-; (82.5,80]: B^+; (80,70]: B; (70,67.5]: B^-; (67.5,65]: C^+; (65,55]: C; (55,52.5]: C^-; (52.5,40]: D; (40,0]: F

COVID-19: Please adhere to the precaution guidelines issued by CDC and UGA strictly. Do not attend classes if you have COVID-19 symptoms or have tested positive. Wearing a mask or an appropriate face covering in class is recommended.

Academic Honesty: All members of the academic community are committed to honesty. The academic honesty policy statement of UGA can be viewed online at www.uga.edu/honesty.

Outline of Courses PHYS 8301/8302 (changes possible)

I. Thermodynamics and Statistical Mechanics (PHYS 8301)

- Macroscopic States and Thermodynamic Laws (macrostates, temperature, ideal gas, van der Waals equation of state, state variables and integrability, work, heat, 1st Law, heat capacities, adiabatic processes, Carnot cycle, entropy and 2nd Law, 3rd Law, absolute zero)
- Thermodynamic Potentials (independent variables, Legendre transformation, free energy, enthalpies, extensitivity and homogeneity, equilibrium properties)
- Phase Transitions (phases and phase diagrams, phase equilibrium, Clausius-Clapeyron equation and first-order phase transitions, Maxwell construction and its physical interpretation, Ehrenfest classification, critical properties and second-order phase transitions, critical exponents, exponent (in)equalities)
- Statistical Physics (statistical ensemble theory, microstates and microstate probability, Liouville equation, quantum statistics, microcanonical ensemble, canonical ensemble, grand canonical ensemble)

II. Quantum Statistics (PHYS 8302)

- Quantum Gases (quantum grand canonical ensemble, identical particles, Fock states, second quantization, (anti-)commutation relations, operators in second quantization, second quantization in momentum space, ideal quantum gases)
- Ideal Fermi Gas (fermionic equation of state, classical limit, density of states and Fermi function, Fermi gas at low temperatures, application: Pauli spin paramagnetism)
- Ideal Bose Gases and Bose-Einstein Condensation (thermal and caloric equations of state, classical limit, Bose-Einstein condensation, Bose-Einstein phase transition, thermodynamic properties of the condensate)
- Photons and Phonons (photon gas, radiation fields, Planck's Law, quantization of lattice vibrations, phonons, Debye model of solids and thermal properties)