PHY442 Statistical Mechanics

Spring 2018

Dimitrios Vavylonis
Department of Physics
415 Lewis Lab
vavylonis@lehigh.edu
(610) 758-3724

Time and Location: MWF 10:10-11:00 LL 514

Course website http://athena.physics.lehigh.edu/

Course Outline

1. Introduction to Statistical Mechanics. Probability in statistical mechanics. Definition of entropy and temperature. Kinetic definition of pressure. Correlations. Time and phase-space averages.
2. Thermodynamics. Thermodynamic variables. Legendre transforms and free energies.
3. Canonical Ensemble. Partition function. Equipartition theorem. Applications to gas, solid and magnetic systems.
4. Grand Canonical Ensemble. Grand canonical partition function. Applications to solutions, chemical reactions, and systems with adsorption.
5. Statistical Physics of Bosons and Fermions. Quantum statistical mechanics. Black body radiation. Phonons. Bose-Einstein condensation. Systems of interacting and non-interacting electrons.
6. Phase Transitions. Phases and phase diagrams. Phase equilibrium. First and second order phase transitions. Mean field and Landau theory. Scaling, universality and renormalization.

Initial Competences

• Undergraduate courses on thermodynamics, classical mechanics, quantum mechanics, probability theory, multivariable calculus and computer programming.

Final Competences

• Understand the microscopic origin of thermodynamics (i.e. quantities such as entropy, heat capacity, equations of state, etc).

• Understand the assumptions and implications of the fundamental equation of statistical mechanics, $S = k \ln W$, and the relation to small fluctuations around the average (of thermodynamic variables).
• Understand how dynamics and ergodicity lead to the second law of thermodynamics.
• Ability to apply the methods of statistical mechanics using the microcanonical, canonical and grand-canonical ensembles for both classical and quantum systems.
• Ability to apply approximate methods to solve many-body interacting systems.
• Understanding of statistical mechanics descriptions of phase transitions and critical behavior.
• Ability to use computer simulations in applications of statistical mechanics using probabilistic, numerical integration, and Monte Carlo methods.
• Background to independently explore applications of statistical mechanics to physical systems discussed in class and beyond (such as heat capacity of solids, Bose-Einstein condensation,polymer elasticity, neutron stars, electrical properties of materials and others.)

Textbooks

Robert H. Swendsen, "An Introduction to Statistical Mechanics and Thermodynamics," Oxford University Press, 2012

Leonard M. Sander, "Equilibrium Statistical Physics: with Computer Simulations in Python", 2013

These books integrate the teaching of graduate level statistical mechanics with computer simulations. Many other books are available and recommended for further reading, for example:
Pathria and Beale, Statistical Mechanics, 3rd ed, (Academic Press, 2011)
Huang, Statistical Mechanics, 2nd ed. (Wiley, 1987)
Kardar, Statistical Physics of Particles (Cambridge University Press, 2007)

An extensive list of books in statistical mechanics, including some that are available online for free, can be found at http://stp.clarku.edu/books/

Grading

Upon satisfactory attendance, the course grade will be based on:
1. Weekly homework problems (25%).
2. Two one-hour exams (30%).
3. Final exam (45%).

Office Hours

MW 3:00-4:00

Accommodations for Students with Disabilities: If you have a disability for which you are or may be requesting accommodations, please contact both your instructor and the Office of Academic Support Services, University Center C212 (610-758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.

The Principles of Our Equitable Community:
Lehigh University endorses The Principles of Our Equitable Community (http://www.lehigh.edu/ inprv/initiatives/PrinciplesEquity_Sheet_v2_032212.pdf). We expect each member of this class to acknowledge and practice these Principles. Respect for each other and for differing viewpoints is a vital component of the learning environment inside and outside the classroom.