Syllabus for Statistical Physics I – PHYS 663-0001

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Semester:	Spring 2016 (Jan 18th – May 15th)
Class Number	*4495*
Lectures:	Tue & Thu, 12:30 – 13:45
Location:	La Tourette Hall 227
Office hours:	Tue & Thu, 13:45 – 14:15, 15:30-16:00, La Tourette Hall 217
Webpage:	http://www.aglatz.net/home/teaching/statphys_S2016/

Contents

1. Introduction and background
   1.1. Role and tasks of Statistical Physics
   1.2. Short history of Statistical Physics
2. Boltzmann's approach to Statistical Physics
   2.1. Classical mechanics, Liouville theorem
   2.2. Micro- and macro-variables, thermal equilibrium
   2.3. Boltzmann entropy
   2.4. Quantum description
   2.5. Connection to thermodynamics, first and second law of thermodynamics
3. Gibbsian Ensemble
   3.1. Microscopic and macroscopic densities
   3.2. Gibbs ensemble
   3.3. Quantum description
4. Equilibrium Ensembles
   4.1. Microcanonical ensemble
   4.2. Canonical ensemble
   4.3. Grand canonical ensemble
   4.4. Nernst theorem and third law of thermodynamics
5. Ideal Gases
   5.1. Classical ideal gases
   5.2. Ideal quantum gases
   5.3. Equation of state
   5.4. Bose-Einstein condensation, superfluidity
   5.5. Photons
   5.6. Fermions at low temperatures
6. Thermodynamics
   6.1. Thermodynamic potentials and thermodynamic stability
   6.2. Response functions
   6.3. Phase equilibrium
   6.4. Van der Waals gas, Maxwell construction
7. Introduction to phase transitions
   7.1. Phase diagrams, phase transitions (1st/2nd order)

7.2. Critical phenomena (second order phase transitions)
7.3. Ginzburg-Landau theory

Course Description

- The course will be given as classroom lecture.
- Since this is a graduate level course the course does not follow only a single textbook (see recommended textbooks), but follows the topics as given in the lecture contents. These are standard topics and are covered in several of the textbooks given below, but not necessarily all in the same book nor in the order of the lecture.
- Therefore, regular lecture attendance is highly recommended (see also grading).
- There will be a midterm and a comprehensive final exam. Exams are closed book and electronic devices are not allowed. Formula sheets will be provided.
- A single handwritten page (one sided) and be brought to the exams.
- Homework are typically given every other week. Solution are discussed in the next lecture after due date
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Preferred prerequisites: advanced math background, classical mechanics, ED, QM, and undergrad statistical physics/thermodynamics

Learning Outcomes

- This lecture covers the underlying principles of modern condensed matter physics and thermodynamics.
- Using the methods taught in this course should enable the students to solve related problems independently in their master/Ph.D. works and beyond.
- Students will also learn how to define their own research questions.
- This course will also enable the students pursuing a career in computational physics to understand and design the foundation of thermodynamic simulations.

Recommended textbooks

- **Frederick Reif,** *Fundamentals of Statistical and Thermal Physics*, Waveland Pr Inc (2008)
- **R. Kubo**, *Statistical Mechanics*, North Holland (1990)
- **K. Huang**, *Statistical Mechanics*, John Wiley & Sons, New York (1987)

Additional textbooks

- **L. Landau & I. Lifshitz**, *Statistical Physics, Part 1: Volume 5,* Butterworth-Heinemann (1980)
- **Sommerfeld**, *Thermodynamics and Statistical Mechanics*, Academic press,

New York (1956)

Advanced textbooks

- **P. Chaikin and T. Lubensky**, *Principles of Condensed Matter Physics*, Cambridge University Press (1995)
- **R. P. Feynman**, *Statistical Mechanics – A set of lectures*, Frontiers in Physics,
- Benjamin/Cummings, Reading Massachusetts (1982)
- **N. Goldenfeld**, *Lectures on Phase transitions and the Renormalization Group*, Frontiers in Physics, Addison Wesley, Reading Massachusetts (1994)
- **L. Landau & I. Lifshitz,** *Statistical Physics, Part 2: Volume 9*, Butterworth-Heinemann (1980)

Grading

The final grade is determined according to

- 45%: homework percentage
- 10%: lecture attendance percentage
- 20%: midterm exam percentage
- 25%: final exam percentage

This results in a total score between 0 and 1, which is then multiplied by 12, rounded to the closed integer, divided by 3, and finally graded according to*
http://www.niu.edu/regrec/grading/gradingfaqs.shtml
Note: To pass this course, you MUST score at least 50% on the homework.
* values below 2 are round to the closed integer.

Accessibility Statement
Northern Illinois University is committed to providing an accessible educational environment in collaboration with the Disability Resource Center (DRC). Any student requiring an academic accommodation due to a disability should let his or her faculty member know as soon as possible. Students who need academic accommodations based on the impact of a disability will be encouraged to contact the DRC if they have not done so already. The DRC is located on the 4th floor of the Health Services Building, and can be reached at 815-753-1303 (V) or drc@niu.edu.