Physics 375: Thermal Physics — *Spring 2010*

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	Room	Time
Lecture	Eaton 105	11:15-12:10 MWF

Text

- Charles Kittel and Herbert Kroemer, *Thermal Physics*, 2nd Edition (Freeman)

Recommended Texts

- David L. Goodstein, *States of Matter* (Dover Publications)
- Frederick Reif, *Fundamentals of Statistical and Thermal Physics* (McGraw-Hill)
- Daniel V. Schroeder, *An Introduction to Thermal Physics* (Addison Wesley)
- Charles Kittel, *Elementary Statistical Physics* (Dover Publications)

Course Objectives
This course is a rigorous introduction to thermal physics using statistical mechanics. After completion of the course, students will be able to analyze simple models for a wide range of physical systems using statistical techniques.

About Physics 375
Thermal Physics is the study of the properties of systems composed of very very large numbers of particles. The main thrust of the course will be the study of statistical mechanics, or the study of the average mechanical properties of a system. We will also briefly touch upon thermodynamics, which is much more phenomenological and more general. Statistical mechanics and thermodynamics apply to an amazingly large range of systems, including neutron stars, black holes, heat engines, rubber bands, gases, chemical reactions, nuclear reactions, electrons in metals, photon gases, magnetic materials, and superfluid liquid helium to name a few. We will start from the consideration of the multiplicity of allowed states in a system and define entropy and temperature. From these definitions follow most of the rest of the course.

As an undergraduate, I did not want to learn thermal physics because I thought that heat engines were not a very interesting topic, certainly not as interesting as electricity and magnetism. My advisor insisted, though. Heat engines were only a small part of the course I took. After I finished the course on thermal physics, I thought that it was the most interesting thing I had learned up to that time. I hope you all will be as happy with the material as I am!

Course Requirements
  Regular Homework Problems
  2 Exams
  Final Exam

Grading
Grades in this class will be based on the following elements.

- **Participation** I expect each student to do the assigned readings and problems and to bring questions and comments to class and to participate in class discussions. Implicit in this is the expectation that all students will attend all classes. The grade for participation will be assigned at my discretion at the end of the semester.

- **Homework** Homework will be assigned on a regular basis and collected. I reserve the right not to give credit for late homework assignments, based on the belief that keeping up is an essential ingredient for success in the course. You may work together on the homework. Indeed, I encourage you to work together to understand the problems. However, you must each separately write up solutions in your own words (and equations) and may not turn in something you do not understand. (That is, you may not simply paraphrase someone else's solution as your own.) Paraphrasing without understanding, or outright copying, will be considered plagiarism.

- **Exams** There will be two hour exams and a final exam. The final exam will be comprehensive. Dates for the hour exams will be announced in lecture. The hour exams are likely to be take-home exams. The final exam will be in the period set by the Registrar, which should be Tuesday May 11th at 1:30 p.m.

- **Quizzes** There may be quizzes in class, mostly for your own diagnostic use. Any quizzes will be announced in advance and will count towards your participation grade.

The relative weights of each element of the grade for the course is as follows.

Element	Weight
participation	10%
homework	30%
hour exams	30%
final exam	30%

Office Hours
Initially office hours will be Wednesday at 2:30 pm, Friday at 3:00 pm, and by appointment. If these hours are inconvenient for you, please let me know and I'll try to find some more convenient times. In addition, you may stop by any time to see if I am free to discuss physics, life, the universe, or anything else. If my door is closed, I am likely to be busy.

Revision Policy
Policies and schedules set forth in this syllabus are subject to revision.

Tentative Outline

This syllabus is perhaps a bit ambitious. I suspect that we will probably get through most of this material, though perhaps not at the depth covered by some of the text.

Counting States
Examples of systems with discrete energy levels. Spin systems and binary alloys. Multiplicity functions. Sharpness of the multiplicity function. (1 week)

Entropy & Temperature
Fundamental assumption of statistical physics. Probability and counting. Thermal equilibrium. Entropy. Laws of Thermodynamics. (1.5 weeks)

Boltzmann Distribution
Partition Functions. Helmholtz Free Energy. (1.5 weeks)

Thermal Radiation
Planck distribution. Planck law. Stefan-Boltzmann law. Debye theory. (1.5 weeks)

Chemical Potential
Chemical potential. Gibbs factor. Grand partition function. (1.5 weeks)

Ideal Gas
Fermi gases. Bose gases. Classical limit. Applications to white dwarves, metals, nuclear matter. Bose-Einstein condensation. Superfluidity. (3 weeks)

Heat & Work
Heat engines. Isothermal and isobaric processes. Reversible and irreversible processes. Carnot inequality. (1.5 weeks)

Chemical Reactions
Chemical equilibrium. Law of mass action. Gibbs free energy. (1 week)

Phase Transitions
Coexistence curve. Van der Waals equation of state. Mean field method. Landau theory of phase transitions. (1.5 weeks)