Course Information

Physics 335/01 (Thermal Physics)

Fall 2016

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Primary Text: *An Introduction to Thermal Physics*, Daniel V. Schroeder, 2000

Course Website: We will use Moodle – http://moodle.lafayette.edu. "PHYS 335.01- Fall 2016 Thermal Physics" should be in your list of current courses. Handouts, homework assignments/solutions, supplemental articles, exam solutions, etc., can be downloaded from this site. Taking a few moments to explore the site at the beginning of the semester can be a richly rewarding experience and is highly recommended.

Useful supplementary physics texts (All of the texts listed below are excellent. I highly recommend that you familiarize yourself with at least one or two of them.):

1. *Thermodynamics and an Introduction to Thermostatistics 2nd ed.*, H. B. Callen, 1985.
2. *Thermal Physics 2nd ed.*, Charles Kittel and Herbert Kroemer, 1980.
3. *Random Walks in Biology*, Howard C. Berg, 1993.
4. *Thermal Physics*, Ralph Baierlein, 1999.
5. *Statistical Physics – An Introductory Course*, Daniel J. Amit and Yosef Verbin, 1999.

6. *Statistical Mechanics Made Simple, 2nd ed.*, Daniel C. Mattis and Robert H. Swendsen, 2008
7. *Four Laws That Drive the Universe*, Peter Atkins, 2007.
8. *Introduction to Modern Statistical Mechanics*, David Chandler, 1987.
9. *Statistical Mechanics – a Concise Introduction for Chemists*, Benjamin Widom, 2002.
10. *Statistical Thermodynamics*, Erwin Schrodinger, 1964.
11. *Statistical Physics, 2nd ed.*, Landau-Lifschitz, 1969.
12. *Thermodynamics*, Enrico Fermi, Dover in 1956.

Suggested supplementary mathematical physics texts (get from library, ILL, eCampus.com, etc.):

1. *Mathematical Methods for Scientists and Engineers*, Donald A. McQuarrie, 2005.
2. *Mathematical Methods in the Physical Sciences 3rd ed.*, Mary J. Boas, 2005.
3. *Mathematical Methods for Physicists 5th ed.*, George B. Arfken and Hans J. Weber, 2001.

Class Overview and Goals:

In this course we shall develop and present the main concepts and tools of statistical physics, comprised primarily of thermodynamics and statistical mechanics. As such, this course encompasses the traditional approach of thermodynamics, which says virtually nothing about the constitution of physical systems, and the more modern approach of statistical mechanics, which makes predictions based on the assumption that matter is composed of large numbers of particles subject to the laws of quantum mechanics. By applying a probabilistic, non-deterministic approach analytically to an astonishingly broad array of systems will vividly demonstrate the power, elegance and versatility of the stochastic method. By studying problems such as: the reversible binding of oxygen to hemoglobin, the size of random coil polymers, the structure of neutron stars and the behavior of weakly interacting paramagnets we hope to show that the probabilistic approach of statistical physics provides a satisfying understanding of important and interesting phenomena in fields as diverse as biology, chemistry, engineering, geology, solid state physics, nuclear physics, medicine and cosmology. Along the way it is hoped the student will come to appreciate that this venerable and mature branch of physics remains a viable and surprisingly relevant field of study even today.

One should note, also, that thermal physics provides a vast and fertile playground for the development and application of advanced mathematical techniques, many of which can be transferred with suitable modifications to other branches of physics and even to other fields of study, e.g., biology, medicine and economics .

Student Learning Outcomes:

- Students will get a mental grip on simple, but elusive thermodynamic concepts, e.g., temperature, heat and entropy.

- Students will be able to apply the laws of thermodynamics to a wide variety of situations, including those encountered in everyday life.

- Students will understand the principles behind the design and operation of heat engines, heat pumps and refrigerators and further recognize and be able to refute the fallacies behind so-called perpetual motion machines of the first or second kind.

- Students will be able (by combining the laws of quantum mechanics and the laws of statistics) to predict the behavior of widely varied, complex systems consisting of a large number of particles.

- Students will see how the principles of statistical mechanics provide an underlying explanation for thermodynamics, in particular, drawing connections between the properties of a macroscopic system and its microscopic constituents.

- Students will appreciate how the probabilistic analysis provided by statistical mechanics explains a mind-boggling array of phenomena in fields as diverse as biology, chemistry, physics, climatology and medicine.

- Students will sharpen critical thinking skills and further develop their analytical skills as they analyze ever more complicated physical systems.

- Students will appreciate the foundational nature of Physics and its relationship to other disciplines as well as its connection with the solution of real-world problems.

Class Structure:

Delivering a lecture in front of class may be the least effective way of teaching physics. To create a more effective learning environment I intend having you do most of the work while I serve primarily as a guide. With that in mind, I envision two or three typical classroom activities: (1) short lectures by me to clarify or amplify key points in the book; (2) individual students presenting topical discussions and problem solutions at the board and (3) breaking up the class into small problem-solving groups which will present results on the blackboard or lead in-class discussions.

Homework - Other Assignments and Exams:

Preparing for class and doing the homework are critical to your success. Homework assignments will be given weekly and are to be handed in at the start of class on the due date. **Late homework will not be accepted**. Solutions to homework will be posted on Moodle the day the assignment is collected. Some assignments will be computer-based. It will behoove you to become familiar with, if you haven't already done so, with one or more powerful software programs, such as Mathematica, MathCad or Maple. Even spreadsheets like Excel may be profitably used for some assignments.

The course has two exams, a midterm and a final, on dates specified in the Syllabus. Both exams are closed book and closed notes, taken in class. Each student may write one sheet (8.5"x11") of notes in his/her own hand.

The recitation sessions are informal, but not optional. In addition to clarifying and elaborating salient points made in lecture, I will also answer questions related to homework assignments. Further, students will be expected to present simple assigned problems to the rest of the class during these sessions. A lot of valuable learning can occur in such an environment.

Collaboration:

Collaboration among students on homework is not only allowed, it is vigorously encouraged. However, any work you turn in must be written by you, in your own words, and faithfully represent your understanding of the relevant material. In contradistinction, collaboration on exam questions is never permitted. Directly copying homework solutions or exam answers will result in stiff penalties ranging from a zero for the assignment or exam to failure for the course. If you desire clarification of any of these points, please read the statement on "Academic Honesty" posted on Moodle or consult with me.

I encourage all of you to seek help when needed. Generally, the earlier you come the better the results. My office hours are listed on my schedule (included with the first day's handout) and also are posted on the bulletin board next to my office. My class schedule and all other significant postings are also available on PHYS335.01 – Fall 2016 (Moodle). Interacting with students has been and remains a source of great satisfaction for me.

Grading:

50% Homework and Class Participation (including recitations)
20% Midterm Exam
30% Final Exam (Cumulative)

Course Syllabus

Dates	Topics	Text
Aug. 29/31/ Sept. 2/5	Energy in Thermal Physics	Ch. 1
Sept. 7/9/12/14/16/19	Probability & Second Law	Ch. 2
Sept. 21/23/26/28/30	Interactions & Implications	Ch. 3
Oct. 3/5	Engines and Refrigerators	Ch. 4
Oct. 7/Fall-Break/12/14/17/19	Free Energy & Transformations	Ch. 5
Oct. 21 Midterm Exam	Midterm Exam	Inclusive
Oct. 24/26/28/31/ Nov. 2/4/7/9	Boltzmann Statistics	Ch. 6 and Notes
Nov. 11/14/16/18/21	Quantum Statistics	Ch. 7 and Notes
Nov. 23 - 25	Thanksgiving Break	
Nov. 28/30/ Dec. 2/5/7/9	Systems of Interacting Particles	Ch. 8 and Notes
TBA	Final Exam	Inclusive