Statistical Physics
PHY5514-0001 Spring 2020
Lectures: MWF 12:30 PM -1:20 PM ENG1 0227

Lecturer: Prof. Aniket Bhattacharya,
Office: PSB 452
Office Hours: W 2:00 PM – 3:00 PM
F 2:30 PM – 3:30 PM Or by appointment

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Course Description:

PHY 5524 is a graduate level course in Statistical Mechanics. It is one of the core courses for the UCF graduate program in physics. The course covers introductory elements of modern statistical mechanics and provides a microscopic basis and statistical interpretation of classical thermodynamics using ensemble approach

Course Objective:

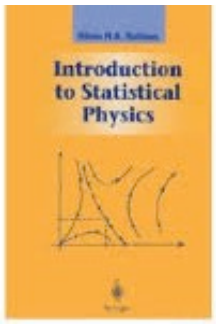
The course prepares the incoming graduate students to review and learn elements of thermodynamics & statistical mechanics required to pass the departmental Ph. D candidacy examination. It also expected that students will develop basic understanding and skills in statistical mechanics for their research

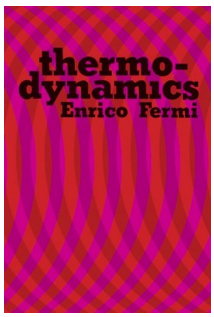
Prerequisites:

The course requires introductory knowledge of heat and thermodynamics, at the level of PHY 3513 or its equivalent. The students without adequate background of undergraduate education on thermal physics are requested to see the instructor on the very first day of classes.

Course Text:

Introduction to Statistical Physics,
2nd Edition
Author: Silvio R. A. Salinas
Publisher: Springer, New York,
ISBN-13: 978-1441928849 (paperback)
ISBN-10: 1441928847 (paperback)
ISBN-13: 978-0387951195 (hardcover)





Thermodynamics
Enrico Fermi
Dover Publication

We will follow Fermi's book for review of thermodynamics. Then we will begin statistical mechanics and follow selected chapters from Salinus' book. These will be supplemented by the lecture notes and additional materials available at the class web course. I expect that the lecture notes that I will post for topics covered during lecture will be very helpful.

Evaluations, Grades and Distribution:

The course grade will be based on the following weights:

- Homework (25%)
- Three Tests 45%
- Comprehensive final exam 30%

A: 85% and above
B: 75% - 84.9%, C: 65% - 75%
D: 50% - 65% F: < 50%

I will use +/- grades to determine A-, B+, B- and C+ for the borderline cases to improve your grades The equivalent score for the comprehensive final, if greater, will replace the lowest test score. However, please note that taking all the tests is mandatory. In the event of an emergency or unforeseen situation, you must inform the instructor ASAP that you will not be able to take the test. You should make every effort to see the instructor personally and show the pertinent documents. After reviewing the situation, the instructor may arrange a makeup test. *Skipping a test and replacing the zero test score for an absence for a test with the equivalent final score is NOT an option.* Please refer also to the "Missed Work Policy" section below.

Homework:

Individual homework (about 7-8) will be assigned for the entire course. They will be graded and solutions will be provided after the due dates. Each homework set will consist of 1-3 problems. The assignments will be due (hard copies only) on MWF at the beginning of each lecture, as appropriate. Homework turned in late will have a penalty of 5% per day until the solution becomes available on webcourses. After the solutions are posted, students are still encouraged to submit late homework for which they will get a 50% credit of the actual score.

Homework problems are given to solidify your concepts and learn the materials. Thus, I encourage you to discuss the homework problems among yourselves, work in a group, seek my assistance, if necessary, - but each student must turn in his/her own assignment. Note that eventually you will be taking the tests, the final, and the candidacy exam, so it is to your advantage to master all the problems and ensure that even when you got help from other resources you can work out the solution by yourselves.

In addition to the assigned homework problem for which you will a grade, I will post additional problems. These problems will not be graded, but will benefit you to acquire mastery on the subject and doing well on the tests and the final.

Course organization and expectation:

The teaching will mostly consist of a set of lectures. I will preferably communicate through Canvas for assigning homework and posting relevant materials for this course. The lecture materials will be primarily contained in the recommended text by Salinas. I'll also provide supplementary materials in the form of hand-written notes or refer to some other textbooks as appropriate.

Many excellent texts/references are available on statistical mechanics including upper level under-graduate textbooks. In particular the following textbooks will be very useful references for this class. I will closely follow some chapters from these references.

1. **Statistical Physics: An Introductory Course, Daniel J. Amit and Yosef Verbin** (World Scientific): This is an excellent reference with lots of worked out problems.
2. **Thermal Physics, C. Kittel and H. Kroemer, 2nd edition, (Freeman):** This book is often used as a textbook for 3000 - 4000 level undergraduate course. It has also many examples and problems
3. **Statistical Mechanics, R. K. Pathria, (Elsevier):** A good popular textbook with lots of examples and problems. I have used this book in the past as the text and will follow some chapters from Pathria's book.
4. **Statistical Mechanics, Landau and Lifshitz (Pergamon press):** Like other volumes, Landau's Statistical Physics – Vol-I is an excellent reference for this course. The book also contains many worked-out problems. I have used these problems for homework and tests.

UCF Webcourses (webcourses.ucf.edu)

Our primary vehicle of exchanging information will be from Canvas for **PHY5514-20Spring-0001** accessed through Webcourses.ucf.edu. Once you log in, items on the left panel of the home screen will take you to various sections, such as, Assignments, Grades, etc. In particular you will be able to access the course outline, answers to quizzes and homework, all the lecture notes and handouts by clicking "Files". *You need to visit this page regularly for any new item posted. "Announcements" will keep you updated on a regular basis.*

Academic Activity quiz:

All instructors/faculty are required to document students' academic activity at the beginning of each course. In order to document that you began this course*, please complete the quiz entitled "AA" by*

the end of the first week of classes or as soon as possible after adding the course. Failure to do so may result in a delay in the disbursement of your financial aid.

Other relevant information:

Student Accessibility Services (SAS):

UCF provides additional testing accommodations as needed. If you need special testing accommodation please contact me at the beginning of the 1st week of classes. If you would be taking the test at the SAS center, you should begin the test at the same scheduled time of the actual test.

Missed Work Policy:

It is Physics Department policy that making up missed work will only be permitted for University-sanctioned activities and bona fide medical or family reasons. Authentic justifying documentation must be provided in every case (in advance for University-sanctioned activities). Please contact me, preferably prior to a scheduled test, or as soon as possible in case of an unforeseen circumstance, so that I can arrange a makeup test for you. Please contact me within a week period if you have a grading dispute.

Professionalism Policy:

Per university policy and classroom etiquette, mobile phones, iPods, etc. must be silenced during class. Those not abiding this rule will be asked to leave the classroom immediately so as to not disrupt the learning environment. Please arrive on time for all class meetings. During exams only nonprogrammable calculators (such as, TI-30X, TI-30Xa, or equivalent) can be used. Unless prior agreement, no books, lecture notes or anything else is allowed during the test.

Academic Conduct Policy:

Academic dishonesty in any form will not be tolerated by UCF. If you are uncertain as to what constitutes academic dishonesty, please consult "The Golden Rule", the University of Central Florida's Student Handbook (http://www.goldenrule.sdes.ucf.edu/) for further details. As in all University courses, The Golden Rules of Conduct will be applied. Violations of these rules will result in a record of the infraction being placed in your file and receiving a zero on the work in question AT A MINIMUM. At the instructor's discretion, you may also receive a failing grade for the course. Confirmation of such incidents can also result in expulsion from the University.

Tentative schedule:

Please refer to the details of the tentative weekly schedule and reading assignments below. Please mark your calendar for the following important *test dates and the comprehensive final*

Test-I: Monday, February 03, 2020
Test-II: Monday, March 02, 2020
Test-III: Friday, April 03, 2020
Comprehensive Final Exam: Friday, April 24, 2020 10:00 AM – 12:50 PM

Classes begin: Monday, Jan 06, 2020
Classes end: Monday, April 20, 2020 (last lecture)

Holidays (No lecture)
Martin Luther King Jr. Day – Monday Jan 20
Spring break – March 09 – March 14

Tentative topics to be covered and reading assignments: I may edit as we go along

Weeks	Topics Covered	Comments
Week 1 Jan 06 – Jan 10	Brief history of Statistical Mechanics. Introduction to the zeroth and 1st law of thermodynamics, its implication that heat is a form of energy. Internal energy and work. Application of the 1st law to systems whose state can be represented on a (V,p) diagram. Application of 1st law to gases, adiabatic transformation of a gas.	Fermi Chapters 1 & 2
Week 2 Jan 13 – Jan 17	The 2nd law of thermodynamics and its implication. Carnot cycle, absolute thermodynamic scale of temperature, absolute zero, entropy and irreversibility.	Fermi Chapter 3
Week 3 Jan 20 – Jan 24	Applications of 1st and 2nd laws of thermodynamics, exact differentials, Properties of entropy, Entropy of a system whose state can be represented on a *(V,p)* diagram; equation of states for an ideal gas and van der Waal gas. The Clapeyron equation.	Fermi Chapter 2 - 4 Jan 20 - No Lecture
Week 4 Jan 27 – Jan 31	Statistical description of a physical system. Specification of microstates $\Omega(E,N)$; Boltzmann's interpretation of entropy $S = k_B \ln \Omega$ and calculation of entropy, examples: spin ½ system, one dimensional (1D) quantum harmonic oscillator, and other examples.	Salinas Chapter 2.1
Week 5 Feb 03 – Feb 07	Specification of the microscopic state for a classical ideal gas. One dimensional classical harmonic oscillator. The ergodic hypothesis.	**Test-I: Feb 03** Salinas Chapter 2.2
Week 6 Feb 10– Feb 14	Phase space and the micro-canonical ensemble. Thermal interaction between two microscopic systems. Connection between statistical mechanics and thermodynamics.	Salinas Chapter 4
Week 7 Feb 17 – Feb 21	The canonical ensemble. The partition function and the Boltzmann distribution. Applications of canonical ensembles. The classical (Langevin) theory of paramagnetism.	Salinas Chapter 5
Week 8 Feb 24 – Feb 28	Quantum (Brillouin) theory of paramagnetism. The classical and the quantum harmonic oscillators. Classical limits of the quantum systems.	Salinas Chapter 5
Week 9 Mar 02 – Mar 06	The classical ideal gas in a canonical ensemble.	Salinas Chapter 6 **Test-II: Monday March 02**

Week 10 March 09 – March 13	Spring Break	No classes
Week 11: March 16 – March 20	The grand canonical (GC) ensemble. An ideal gas in a grand canonical ensemble. Indistinguishability. The Grand partition functions for a Bose and a Fermi gas	Salinas Chapters 7 & 8
Week 12: March 23 – March 27	The chemical potential and grand potential. An ideal quantum gas in a GC ensemble	Salinas Chapters 7 & 8
Week 12: March 30– April 03	Properties of a noninteracting dilute fermi gas. Fermi surface and Fermi temperature. Specific heat and pressure of a dilute Fermi gas.	Salinas Chapter 9 Selected topics
Week 13: April 06 – April 10	Properties of a noninteracting dilute Bose gas, Bose-Einstein condensation. Specific heat and pressure of a dilute Bose gas.	Salinas Chapter 10 Selected topics Test-III Friday April 10
Week 14: April 13 – April 17	The Ising model. Exact solution of 1D Ising model. Spin-spin correlation functions. Weis molecular field and mean field solution of Ising model.	Salinas Chapter 13
Week 15: April 20	Mean field critical exponents of Ising model	**Last lecture** **April 20, 2020**

Comprehensive Final Exam: Friday, April 24, 2020 10:00 AM – 12:50 PM

Please do not hesitate to stop by if you have any questions at PSB 452.