Statistical Physics

PHY 5524-0001 (3 credit hours)

Spring 2012, TuTh 1:30 pm - 2:45 pm, Jan 09 - April 30, MAP 306

Instructor - Dr. Aniket Bhattacharya

Recommended text: Statistical Mechanics *(Third Edition)*

Authors: *R. K. Pathria and Paul D. Deale*

Publisher: *Butterworth-Heinemann*

Office: PSC 304 Phone: 823-5206

Office Hours: Tu 10:00-12:00 email: *a*niket@physics.ucf.edu

or anytime walk in

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.

Evaluation & Grade: The cumulative course grade will be based on homework assignments (40%), three closed book midterm exams (40%) and a **comprehensive final** (20%).

Homework:

There will be **3 individual homework sets** and **3 group homework sets** for the entire course. Each homework set will consist of 3-4 problems. The assignments will be due either on a Tuesday or a Thursday. All problems have to be solved and the assignment must be turned in at the beginning of the lecture period. I will provide the solution to all the homework problems. Homework turned in late will have a penalty of 10% per day until the solution is sent electronically after which no homework will be accepted. For the individual assignments 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 midterms, the final and the candidacy exam so it is to your advantage to master all the problems. During the first week of classes we'll form approximately 6-8 groups. Please note that while submitting assignments from each group, please make sure that all members of each

group concur with what you jointly submit as a group. Test questions for the midterms and the final will be similar to those assigned as homework problems.

Course organization and expectation:

The teaching primarily will consist of a set of lectures. During the first two weeks basics concepts of thermodynamics will be reviewed and a brief historical development of statistical thermodynamics will be given. I will use a "write-on-tablet" and will post the lecture materials online. The lecture materials will be mostly contained in the recommended text by R. K. Pathria and Paul D. Deale; occasionally I'll provide supplementary materials in the form of hand written notes or refer to some other textbooks listed below. You are urged to browse through these texts; it is likely that you'll get a slightly different perspective of a particular concept compared to the way I'll teach.

Other useful references:

1. Thermodynamics, Enrico Fermi (Dover)
2. Statistical Physics: An Introductory Course, Daniel J. Amit and Yosef Verbin (World Scientific)
3. Equilibrium Statistical Physics, M. Plischke and B. Bergersen, World Scientific
4. Phase transition and critical phenomena, Nigel Goldenfeld (Addition Wesley)
5. Introduction to Statistical Physics, Silvio R. A. Salinas (Springer)
6. Statistical Mechanics, S. K. Ma (World-Scientific, Singapore)
7. Statistical Mechanics, Landau and Lifshitz (Pergamon press)
8. Statistical Mechanics an intermediate course, by Morandi, Napoli, and Ercolessi (World Scientific)
9. Statistical Mechanics Donald A. McQuarrie.

Other relevant informations:

Disability Access Statement: As stated on the website *http://www.sds.ucf.edu/Faculty_guide*, "The University of Central Florida is committed to providing reasonable accommodations for all persons with disabilities. This syllabus is available in alternate formats upon request. Students with disabilities who need accommodations in this course must contact the professor at the beginning of the semester to discuss needed accommodations. No accommodations will be provided until the student has met with the professor to request accommodations. Students who need accommodations must be registered with Student Disability Services, Student Resource Center Room 132, phone (407) 823-2371, TTY/TDD only phone (407) 823-2116, before requesting accommodations from the professor."

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). At the discretion of the instructor, the make-up may take any reasonable and appropriate form including, but not limited to the following: allowing a 'dropped' exam, a replacement exam, replacing the missed work with the same score as a later exam. All assignment and exam grades are final a week after they have been returned. 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 heeding this rule will be asked to leave the classroom/lab immediately so as to not disrupt the learning environment. Please arrive on time for all class meetings. During exams only calculators and mathematical handbooks can be used. 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 instructors discretion, you may also receive a failing grade for the course. Confirmation of such incidents can also result in expulsion from the University.

Important dates:
Classes begin: Jan 09, 2012
Late Registration: Jan 09 - Jan 13, 2012
Drop/swap deadline on myUCF: Jan 12, 2012
Add deadline on myUCF: Jan 13, 2012
Withdrawl deadline: March 20, 2012
Grade forgiveness deadline: March 20, 2012
Spring break: March 5 - March 10 (no lecture)
Classes end: April 19, 2012
Final exam: April 24, 2012, 1:00 PM - 3:50 PM (MAP 306)

Tentative Test schedule:
Test-I: Feb 09, 2012, 1:30 pm - 2:45 pm, MAP 306
Test-II: March 20, 2012, 1:30 pm - 2:45 pm, MAP 306
Test-III: April 17, 2012, 1:30 pm - 2:45 pm, MAP 306
Comprehensive Final: April 24, 1:00 pm - 3:50 pm, MAP 306

Holidays:
Martin Luther King Jr. Day - Jan 16

Please refer to the next page for course outline

Course Outline:

The following is a brief outline of the materials that I'll cover. Typically for 4-6 weeks we will follow the order in which it is itemized below. Then depending upon our progress we may want to cover certain materials before other. At the end of each lecture I will tell you the topic of the following lecture.

- **Review of basic notions in classical thermodynamics:** Zero-th, first law, definition of heat and internal energy, second law, Carnot cycle, absolute thermodynamic temperature, entropy and irreversibility, entropy of systems on a (V, p) diagram, liquid-vapor equilibria and Clapeyron's equation, Helmholtz and Gibbs free energy, response functions (a thin but extremely well written book is Fermi's book on Thermodynamics, Dover publication).

- **Statistical Mechanical Ensembles:**

  - micro-canonical ensemble and its application:
    enumeration of micro states, example collection of spins, most probable distribution and entropy, classical ideal gas in the microcanonical ensemble, entropy of mixing, Gibbs's paradox.
  - canonical ensemble and its application:
    System interacting with an environment, Boltzmann factor and partition function, a two-level system, Langevin theory of magnetism, Brillouin theory of paramagnetism, Harmonic oscillator, Electromagnetic radiation in side a cavity, Debye theory of specific heat
  - grand canonical ensembles and their applications. classical ideal gas, specific heat, classical equipartition theorem, Dulong & Petit's Law, Landau theory of diamagnetism, Brillouin theory of paramagnetism,

- **Quantum Statistical Mechanics:** Bose-Einstein and Fermi-Dirac statistics, non interacting Bose and Fermi gas, Fermi surface, Low temperature specific heat of electrons, Bose-Einstein condensation.

- **Mean-field & Landau Theory:** Mean field Theory of the Ising model, Bragg-Williams Approximation, order-disorder transition, Bethe Approximation, Critical behavior of mean field theories, Virial expansion, Landau theory of phase transition, Symmetry consideration; Maier-Saupe model for liquid crystals, multi-critical points, Landau theory of tri-critical point, Blume-Emery-Griffiths model, He_3-He_4 mixture.

- **Models with continuous symmetry:** The planar vector (XY) model, the quantum vector model, continuous symmetry and soft modes, defects in condensation, Mermin-Wagner Theorem, Kosterlitz-Thouless transition

Please note that this course outline is subject to change. The latest version will be available at the class website