Spring 2016
PHY 731 – Thermodynamics & Statistical Mechanics

Time & Place: Tue & Thu 11:00am-12:20pm, Rm 106 Physics Building
Instructor: M. Cristina Marchetti, mcmarche@syr.edu
Office Hours: email me for an appointment

Course Outline
Statistical physics takes as its subject matter the collective behavior of many-particle systems. Its foundations were laid down more than a hundred years ago with the development of thermodynamics and statistical mechanics which led to a detailed understanding of the thermal behavior of matter. Today, statistical physics has extended its domain to include a very broad range of problems, from the very large, like the distribution of matter in the Universe, to the very small, such as the elastic properties of DNA molecules. The power of statistical physics comes from its conceptual framework and its tool, which include path integrals, transfer matrices, field theory, renormalization group, Langevin and Master equations. The goal of this course will be to introduce the concepts and tools of statistical physics with applications, among others, to classical and quantum gases and to soft and hard matter systems.

The course will assume knowledge of material from an undergraduate course in Thermodynamics and Statistical Physics (such as PHY 531).

A tentative plan of topics to be covered is as follows:

- Review of thermodynamics: thermal equilibrium, the laws of thermodynamics; temperature, energy, entropy, and other functions of state.
- Probability theory: probability densities, cumulants and correlations; central limit theorem.
- Elements of the kinetic theory of gases.
- Classical Statistical Mechanics: postulates; microcanonical, canonical and grand canonical ensembles; non-interacting examples.
- Interacting Systems: virial and cluster expansions; van der Waals theory; liquid-vapor condensation.
- Quantum Statistical Mechanics: quantization effects in molecular gases; phonons, photons.
- Identical Particles: degenerate quantum gases; Fermi liquids; Bose condensation; superfluidity.
- Phase Transitions and Critical Phenomena
- Introduction to nonequilibrium statistical mechanics: Brownian motion; Langevin equation.

Material for course
The material I will cover can be found in any of the three textbooks below, although in each book topics may be covered in different order. As we go along, I will point you to the chapter in each
text where you can find the topics covered in class. I recommend that each of you have one of these books for easy reference.

- *Statistical Mechanics* by R. K. Pathria, 3rd edition. This is a standard graduate textbook used by many generations of graduate students. A little length, but clear and comprehensive
- *Statistical Mechanics in a Nutshell*, Luca Peliti, Princeton University Press. This is a more succinct textbook that covers both introductive and more advanced material

**Required Course Work and Evaluation Procedure**

**Attendance & Participation:** Students are expected to come to class and participate in in-class discussion.

**Homework:** There will be required weekly assignments. These are extremely important. Assignments and readings will be posted weekly on Blackboard and should be downloaded there. Homework assignments will be collected and some will be graded. Solutions will be posted. Discussion of homework problems among the students is encouraged. However, every homework must be written individually. Copying other person's solutions is prohibited. Your solutions to the problems which are already solved in the textbook (check out the last hundred pages there!) need to demonstrate your understanding - you need to fill-in all missing steps (which are many) of the textbook solutions.

- Homework sets are due at the start of class on Tuesdays, unless indicated otherwise

**Quizzes:** There will be frequent in-class quizzes on assigned and covered material. The quizzes may be given on any day at the start of lecture and may be unannounced.

**Evaluation** will be based on in-class participation, quizzes, homework, an in-class midterm and a final exam: Homework 15%, Quizzes 15%, Midterm 30%, Final 35%, In-class participation 5%.

**Academic Integrity**

Syracuse University’s Academic Integrity Policy holds students accountable for the integrity of the work they submit. Students should be familiar with the policy and know that it is their responsibility to learn about course-specific expectations, as well as about university policy. The university policy governs appropriate citation and use of sources, the integrity of work submitted in exams and assignments, and the veracity of signatures on attendance sheets and other verification of participation in class activities. The policy also prohibits students from submitting the same written work in more than one class without receiving written authorization in advance from both instructors. The presumptive penalty for a first offense by an undergraduate student is course failure, accompanied by a transcript notation indicating that the failure resulted from a violation of Academic Integrity Policy. The standard sanction for a first offense by a graduate student is suspension or expulsion. For more information and the complete policy, see [http://academicintegrity.syr.edu/academic-integrity-policy/](http://academicintegrity.syr.edu/academic-integrity-policy/)

**Disability-Related Accommodations**

If you believe that you need accommodations for a disability, please contact the Office of Disability Services(ODS), http://disabilityservices.syr.edu, located in Room 309 of 804
University Avenue, or call (315) 443-4498, TDD: (315) 443-1371 for an appointment to discuss your needs and the process for requesting accommodations. ODS is responsible for coordinating disability-related accommodations and will issue students with documented Disabilities Accommodation Authorization Letters, as appropriate. Since accommodations may require early planning and generally are not provided retroactively, please contact ODS as soon as possible.

**Religious Observances Policy**

SU religious observances policy, found at [http://supolicies.syr.edu/emp_ben/religious_observance.htm](http://supolicies.syr.edu/emp_ben/religious_observance.htm), recognizes the diversity of faiths represented among the campus community and protects the rights of students, faculty, and staff to observe religious holidays according to their tradition. Under the policy, students are provided an opportunity to make up any examination, study, or work requirements that may be missed due to a religious observance provided they notify their instructors before the end of the second week of classes. For fall and spring semesters, an online notification process is available through MySlice/StudentServices/Enrollment/MyReligiousObservances from the first day of class until the end of the second week of class.

The modality for making up academic requirements due to religious observances will be agreed upon individually with each student.