

Physics 731: Thermodynamics and Statistical Mechanics

Spring 2020

General Information

Course Time and Place: Tues. and Thurs. 11:00 am-12:20 pm in Physics 106
 Instructor: Prof. J. M. Schwarz
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 E-mail: phy731.spring2020@yahoo.com
 Office Hours: Tuesdays 4:30-5:30PM pm or by appt.

Prof. Jen's Top 7 Reasons to Take This Course

The following list was inspired by comedian David Letterman's 10 Ten List, which has since become extinct with Letterman's retirement in 2015. Since I do not have a staff of writers backing me, I decided to stop at 7. Perhaps all of you can fill in the rest.

- (7) Both topics are covered on the qualifying exam.....You want to pass it, don't you?
- (6) To climb inside the brains of geniuses such as Joule, Maxwell, Boltzmann, Feynman, Einstein by reading their very own writings.....Remember, it takes one to know one.
- (5) So you can tell your physicist friends what quantum thermodynamics is.....Yes, that's right, *quantum* thermodynamics.
- (4) To learn about interesting *collective* effects of fundamental particles such as electrons. Sometimes "the whole is greater than the sum of its parts".
- (3) To understand that "more is less" in terms of the thermodynamic limit.
- (2) So that you will never be swindled by someone trying to sell you a perpetual motion machine, but to also recognize a good deal when you see one.....A whee-bit cryptic, but you'll soon understand what I mean.
- (1) So you can come up with yet another joke about entropy—one that even Randall Munroe would be proud of.

On a more serious note, all of you have taken a statistical mechanics course before. We will revisit a lot of the same topics and analyze them at a slightly deeper level. I plan to spend about 5 lectures on thermodynamics, 2 lectures on probability theory, 3 lectures on kinetic theory, 5 lectures on classical statistical mechanics, 5 lectures on classical interacting systems, several lectures on the two-dimensional Ising model, 4 lectures on quantum statistical mechanics in general, and 5 lectures on focusing on ideal quantum gases consisting of either bosons or fermions. These are all approximate numbers that will most likely change over the course of the course. My hope is that we will all become experts in such systems as the ideal gas (classical and quantum) and the Ising model before the semester is over.

Readings

While there is technically no required textbook for the course, I will be drawing on the following textbooks as sources of inspiration when preparing lectures:

- (1) E. Fermi, *Thermodynamics*
- (2) R. K. Pathria, *Statistical Mechanics*, 2nd and 3rd Editions

As for the latter textbook(s), some portion of the homework problems will be assigned from Pathria so you will want to have access to it. We will also take a close look at a few chapters from the book by Mehran Kardar on the statistical physics of particles. I will provide copies of those few chapters, so you need not purchase the textbook.

There are other textbooks out there that I may also draw upon from time to time. Because there are too many books to name at this point (other than perhaps Feynman and Riechl and Ma and Landau and Schrodinger and Van Ness), please browse on-line to see what else you can find. You may even take a trip to the library and peruse the stacks just to remind yourself that books used to be made of paper. Call numbers beginning with QC173, QC174, and QC311 should be relevant.

In addition, we will supplement our investigations with original papers by the authors that created the field. While sometimes the material in an original paper is presented in an outdated manner, you may get a glimpse of the inner workings of the minds of some of physics best physicists.

Assessment of Your Work

(1) Homework (40 percent): There will be approximately 10 homework assignments. Each one will be handed out in class and due at some future lecture at the beginning of class. Some assignments will be a little more involved than others, so please allocate your time accordingly. I encourage you to talk to me about them and each other, especially if you are having problems getting started. *In the end, however, each person should write up his/her own solutions in the solitude of his/her own office and/or home.* If you have used any resources other than your brain, which has been nourished by the textbooks, to complete the assignment, please cite them. (I must also remind you that the Syracuse University Academic Integrity Policy holds students accountable for the integrity of the work they submit. For the complete policy, see <http://academicintegrity.syr.edu>.) Finally, after the solutions have been handed out, late homeworks will no longer be accepted.

(2) Class participation (10 percent): Not only are you encouraged to ask questions in class (and via e-mail), I may ask each of you for a consultation when preparing some of the final lectures in terms of pinpointing what is confusing to you, etc.

(3) In-class, mid-term examination (20 percent): While the exam will be closed book, you will be allowed to bring a page of handwritten notes that must be turned in with your exam. The mid-term duration will be one class lecture.

(4) Final Examination (30 percent): The protocol will be the same as the mid-term examination, only it will take up 2 hours. The final exam is scheduled for Friday, May 1, from 5:15-7:15PM in PB106.

Prerequisites

Aside from an undergraduate statistical mechanics course, I presume that everyone knows a bit of classical and quantum mechanics. However, if there are terms that I casually invoke and you have not heard before and/or do not understand, please stop me and ask. This course should be as self-contained as possible.

Syllabus Statement Regarding Disability-Related Accommodations

Students who are in need of disability-related academic accommodations must register with the Office of Disability Services (ODS), 304 University Avenue, Room 309, 315-443-4498. Students with authorized disability-related accommodations should provide a current Accommodation Authorization Letter from ODS to the instructor and review those accommodations with the instructor. Accommodations, such as exam administration, are not provided retroactively; therefore, planning for accommodations as early as possible is necessary. For further information, see the ODS website, Office of Disability Services <http://disabilityservices.syr.edu/>.

SU Religious Observances Policy

The policy, found at 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 holydays 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 both fall and spring semesters, an online notification process is available through MySlice/Student Services/Enrollment/My Religious Observances from the first day of class until the end of the second week of class.

A More Profound Course Objective

To have **fun** learning about a probabilistic means of deriving equilibrium properties of systems with large degrees of freedom, i.e. statistical mechanics. Of course, **fun** does not necessarily mean rolling on the floor with laughter during each lecture, **fun** means that the learning experience should be enjoyable and inspiring for everyone, regardless of gender identity, sexuality, disability, age, socioeconomic status, ethnicity, race, nationality, religion, culture, and academic background. We are all budding scientists seeking to understand our natural world. So let's do it with gusto!