PHYS 622 -- Statistical Mechanics -- Spring 2016

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Class meets:	MWF 11:45 AM - 12:45 PM, Reichardt 203
Office hours:	MWF 9:25 AM - 10:25 AM or by appointment
Credits:	3 credits: 3 hours/week of lecture.
Textbook:	Statistical Physics of Particles, Mehran Kardar, ISBN:9780521873420
Prerequisites:	Graduate standing; PHYS 621
Course Home Page:	http://www.gi.alaska.edu/~chungsangng/phys622/phys622.html

I. Course Description

The UAF Catalog listing for PHYS 622 Statistical Mechanics: "Classical and quantum statistics of independent particles, ensemble theory and applications. Prerequisites: PHYS F621; graduate standing; or permission of instructor."

In terms of the content of the textbook (which you must have and bring to classes), we will try to cover most topics in all Chapters during the fall semester. At the end of this syllabus is a tentative schedule which lists topics we plan to cover. This is subject to change. So you should check frequently the online version of this page: http://www.gi.alaska.edu/~chungsangng/phys622/phys622.html

II. Course Goals

The main goal of this course is to introduce you to the fundamental concepts, phenomena, and theories of statistical mechanics for particles, at the beginning graduate level. Emphasis will be on the theoretical aspects of the subject because the mathematical treatments covered in this course are very fundamental and should help students doing research in other branches of physics.

III. Student Learning Outcomes

- Know how to solve assigned problems in the covered Chapters of the textbook.
- Obtain good understandings on useful concepts, as well as theoretical and mathematical tools related to statistical physics that can help students to conduct their own graduate research

IV. Textbook

You must have a copy of the textbook: Statistical Physics of Particles, Mehran Kardar, ISBN:9780521873420. It is very important that you read the Section(s) covered within each lecture and try to follow derivations before you come to that lecture. Please refer to the schedule below (subject to change) for such reading assignments. You should bring your textbook to the lectures.

The author of this textbook has a website for a course he taught based on materials in this textbook. This website (http://ocw.mit.edu/courses/physics/8-333-statistical-mechanics-i-statistical-mechanics-of-particles-fall-2007/syllabus/) is open to the public in the MIT OpenCourseWare site.

You will find it extremely useful to have some mathematical references, handbooks, or tables, e.g., table of integrals. There are many options available from the Internet, but you should be cautious about the accuracy of information obtained there. One recommendation is Abramowitz and Stegun: Handbook of Mathematical Functions, which can be downloaded freely. Another one is the *NRL Plasma Formulary*, which you can order a free copy or download it online.

References: No reference book is reserved in the library. Here is a list of popular reference books on Statistical Mechanics:

Feynman, Richard P., Statistical Mechanics: A Set Of Lectures, Westview Press, 1998, ISBN: 0201360764 or 9780201360769.

Huang, Kerson, Statistical Mechanics. 2nd ed., Wiley, 1987, ISBN: 0471815187 or 9780471815181.

Khinchin, Alexander I., and George Gamow, Mathematical Foundations Of Statistical Mechanics, Dover, 1949, ISBN: 0486601471 or 9780486601472.

Kittel, Charles, Elementary Statistical Physics, Dover, 2004, ISBN: 0486435148 or 9780486435145.

Landau, L. D., L. P. Pitaevskii, and E. M. Lifshitz, Statistical Physics. Part 1. 3rd ed., Pergamon Press, 1980, ISBN: 0080230385 or 9780080230382.

Ma, Shang-Keng, Statistical Mechanics, World Scientific, 1985, ISBN: 9971966077 or 9789971966072.

Pathria, R. K., Statistical Mechanics, Pergamon Press, 1972, ISBN: 0080189946 or 9780080189949.

Pippard, A. B, Elements of Classical Thermodynamics: For Advanced Students of Physics, Cambridge University Press, 1957, ISBN: 0521059550 or 9780521059558.

Reif, Frederick, Fundamentals of Statistical and Thermal Physics, McGraw-Hill, 1965, ISBN: 0070518009 or 9780070518001.

V. Instructional method and reading assignments

The course is for 3 credits, and so 3 hours per week are devoted to "lectures" in the classroom. However, since this is a graduate level course and that the topics and mathematics are quite advanced, there is not enough time to explains everything in details by lecturing. Students must help themselves by reading and studying before each class. Based on the reading schedule listed below, you need to write down notes as you read about difficulties and questions you found, and try to fill in between steps in derivations. You need to bring these notes and your textbook to each class and participate in discussion based on your notes. I might go around and check your reading notes. Anyone without reading notes (or with very little written on them) or the Textbook will get a reduction of the participation grade of that day. You are also expected to ask questions and contribute to discussion in class about physical concepts and mathematical derivations. I will not have time to go through all the text and derivations, but will only try to answer questions that you found difficult. Any materials that we don't have time to go through in that class have to be left for self-study by students themselves. If you still have difficulties, you need to come to my office hours (or set up another time) and ask for additional help.

Note: some lecture notes might be available for download via the course home page (http://www.gi.alaska.edu/~chungsangng/phys622/phys622.html) by clicking at the dates of the lectures in the schedule. These notes are not to replace the lectures themselves or the textbook.

VI. Homework

Doing homework is the most important factor in doing well in this class. There will be approximately one homework set assigned per week, usually on Fridays, and is usually due in the following Friday before class. However, you should work on your homework as early as possible before a deadline so that you can have time to ask for help during classes or in my office hours if you encounter difficulties in solving these problems. Late homework will not be accepted.

To emphasize the importance of doing homework, homework grade will count towards 40% of the total grade of the course, excluding the assignment with the lowest grade.

Most homework questions will be assigned from those questions in the textbook. Some questions may be selected from other sources. Your submission of any homework problem cannot simply be a one-line statement of the answer. You need to show steps of how you used the method leading to that answer. I will grade the homework based on the method used, as well as the answer. Therefore, you should submit your partially finished work. This will help you getting partial credit, and let me identify your difficulties. Also, your work should be clean and clear enough for me to understand.

While it is good for you to have discussion with classmates or search the Internet for additional information, your submitted homework should be of your own, but not a direct copy from another source. If you finish a question with the help of another person, a solution book, or a solution you found in the Internet or passed on to you from another student, you need to cite that at the end of your answer for that question. There is no deduction of points for using help that you cited if it is not a direct copy. However there can be deduction up to the maximum points of that homework set if you used help but failed to cite. Also, you should use help only to enable you to do a problem yourselves.

Keep in mind that you will be required to do similar questions on your own during exams. In addition, it is against the UAF Honor Code to misrepresent work which is not your own. Plagiarism on homework or on an exam will result in a failing grade.

Solutions to the homework problems will be available to you after the due date. Therefore, late homework will not be accepted. The homework assignments will be given in class, or posted on the course website (click on links within the Schedule).

VII. Examinations

There will be one in-class midterm exam and a final exam. See the schedule below for date and time.

Tips for getting more points in an exam: Exam questions will be graded based on the method used, as well as the answer. Therefore, you should write down explicitly and clearly step by step how you come up with your answers. Even if you don't know how to answer a question (or parts of a question), write down everything you can think of that might help formulate an approach to answer it. If you don't know how to answer the first part of a question, you should move on to answer other parts by assuming an answer to the first part. This will help you getting partial credit.

VIII. Grading

The final grade will be composed of:

Midterm exam	20 %	Mandatory
Final exam	40 %	Mandatory
Homework	40 %	Homework set with lowest grade is dropped
Total:	100 %	

The course will be graded approximately according to the following scale:

> 90 %	A
83 % -- 90 %	A-
76 % -- 83 %	B+
70 % -- 76 %	B
63 % -- 70 %	B-
56 % -- 63 %	C+
50 % -- 56 %	C
43 % -- 50 %	C-
36 % -- 43 %	D+

30 % -- 36 %	D
23 % -- 30 %	D-
< 23 %	F

Note that the passing grade for graduate students is B. Therefore, in order to pass this course, you should get most of the points in homework/project/participation, and to get enough points in exams.

IX. Getting Help

My office hours are listed above. I will be at Reichardt 108 during these office hours. Canceled office hours will be announced in class or by email. If you need to see me outside these office hours, please set up a time by appointment to come to my office at Elvey 706E. These are hours set aside especially to help you - do not feel like you are imposing or cheating by coming in. If you have problems that need immediate attention, please send me an e-mail or give me a call at my office phone number.

I have set up a home page for the course: http://www.gi.alaska.edu/~chungsangng/phys622/phys622.html. I may put additional materials that may be helpful to you later. So, please come back often, especially to check any changes in the schedule. The UAF Blackboard site for this course will be made available to students , but will not be used to provide communication about this course. I will post grades there but those might not be updated very frequently.

X. Disabilities Services

The Physics Department will work with the Office of Disabilities Services (203 WHIT, 474-7043) to provide reasonable accommodation to students with disabilities.

XI. Tentative Schedule

Below is a tentative schedule for 42 classes (subject to change):

Date	Day	Reading Assignment	Main Topics	Homework due (coverage)
1/15	F	1.1-1.2	Introduction, The zeroth law	
1/20	W	1.3-1.4	The first law, The second law	
1/22	F	1.5-1.6	Carnot engines, Entropy	
1/25	M	1.7	Approach to equilibrium and thermodynamic potentials	
1/27	W	1.8-1.9	Useful mathematical results, Stability conditions	
1/29	F	1.10-2.1	The third law, General definitions	HW #1

2/1	M	2.2-2.3	One random variable, Some important probability distributions	
2/3	W	2.4-2.5	Many random variables, Sums of random variables and the central limit theorem	
2/5	F	2.6-2.7	Rules for large numbers, Information, entropy, and estimation	HW #2
2/8	M	3.1-3.2	General definitions, Liouville's theorem	
2/10	W	3.3	The Bogoliubov–Born–Green–Kirkwood–Yvon hierarchy	
2/12	F	3.4	The Boltzmann equation	HW #3
2/15	M	3.5	The H-theorem and irreversibility	
2/17	W	3.6	Equilibrium properties	
2/19	F	3.7	Conservation laws	HW #4
2/22	M	3.8	Zeroth-order hydrodynamics	
2/24	W	3.9	First-order hydrodynamics	
2/26	F	4.1-4.2	General definitions, The microcanonical ensemble	HW #5
2/29	M	4.3-4.4	Two-level systems, The ideal gas	
3/2	W	4.5	Mixing entropy and the Gibbs paradox	
3/4	F	4.6-4.7	The canonical ensemble, Canonical examples	HW #6
3/7	M	4.8-4.9	The Gibbs canonical ensemble, The grand canonical ensemble	
3/9	W	5.1	The cumulant expansion	
3/11	F	5.2	The cluster expansion	HW #7
3/21	M		Mid-term Exam	
3/23	W	5.3	The second virial coefficient and van der Waals equation	
3/25	F	5.4	Breakdown of the van der Waals equation	
3/28	M	5.5	Mean-field theory of condensation	
3/30	W	5.6	Variational methods	
4/1	F	5.7	Corresponding states	HW #8
4/4	M	5.8	Critical point behavior	

4/6	W	6.1	Dilute polyatomic gases	
4/8	F	6.2	Vibrations of a solid	HW #9
4/11	M	6.3	Black-body radiation	
4/13	W	6.4	Quantum microstates	
4/15	F	6.5	Quantum macrostates	HW #10
4/18	M	7.1	Hilbert space of identical particles	
4/20	W	7.2	Canonical formulation	
4/25	M	7.3-7.4	Grand canonical formulation, Non-relativistic gas	HW #11
4/27	W	7.5	The degenerate fermi gas	
4/29	F	7.6	The degenerate bose gas	HW #12
5/2	M	7.7	Superfluid He^4	
5/5	R		Final Exam (10:15 AM to 12:15 PM)	
5/9	M		This is absolutely the last day for submitting your late work, if any, to me (by 5 PM), as well as discussing with me about your grades.	
5/11	W		Final grades will be submitted by noon. They will also be posted on Blackboard.	