Phys 341: Statistical Mechanics - Spring 2012

MWF 11:10 am - 12:00 pm, Stevenson Center 6638

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Office Hours: Tuesday 10:00 am-12:00 noon

Feel free to contact me via email or phone if you have a question or need to schedule an appointment outside the above hours. I normally check email from about 8am-10pm.

Statistical mechanics is the branch of physics that derives the phenomenological results of thermodynamics through a statistical (probabilistic) evaluation of the underlying single-particle mechanics. Thus, we will start with a brief review of calculating probabilities and discuss the relevant thermodynamics as we proceed to cover the basics of statistical mechanics (Chapters 1-8 of Pathria). In the first section of the course (Chapters 1-4), we will cover the statistical mechanics of quantum and classical systems of distinguishable particles including: phase space, ensemble theory, entropy and reversibility. With these tools we can also handle (in an *ad hoc* way) classical systems of indistinguishable particles. In the middle section (Chapters 5-8), we will cover how to properly handle the Fermi and Bose quantum statistics of indistinguishable particles. The last section of the course will be devoted to the role of statistical mechanics in cosmology (Chapter 9) and computational methods (Chapter 16).

Required Text: R.K. Pathria, *Statistical Mechanics*, 3rd Ed.

Supplemental: Gould & Tobochnik, *Statistical and Thermal Physics* http://stp.clarku.edu/notes/. If you feel uncomfortable with your current knowledge of probability theory and/or thermodynamics, I suggest you review Chapters 2 and 3 early in the semester. These online notes are also a good supplement to most of the topics covered throughout the semester.

Important Websites: http://www.vanderbilt.edu/oak/. Course site in OAK. I'll post additional handouts and problem/exam solutions here.

http://phys341statmech.blogspot.com. Course blog. We'll use this site for pre-class reading questions and on-going discussions.

Useful Software: I'd strongly suggest you make sure you have access to Mathematica (or some other symbolic math software) and a spreadsheet program (like Excel or Open Office).

Grading Policies

Exams (3, each worth 25% of the grade).
The course will have three exams: one for Chapters 1-4 of Pathria; one for Chapters 5-8; and a cumulative final that will extend to include Chapter 9 and 16. The exams will start in class and then have a take-home component due the following afternoon at 5 pm. Tentative exam dates are Feb 20, Apr 2 and May 3.

Problem Sets (in total worth 15% of the grade).
Problem sets will be assigned weekly and will be due by **5:00 pm on Tuesdays** (unless explicitly stated otherwise). It is OK to work with others on the problem sets, *provided that you do not simply copy their solutions*. Late problem sets are strongly discouraged. They will be accepted only until Friday (of the same week) at 5:00 pm and will be penalized 50%.

Participation (10%)
This part of your grade will be determined primarily by your comments on the course blog. I will post a question before each class and everyone is expected to submit a response to that post at least two hours before the next class. This is designed to encourage you to read the text and for me to get pre-class feedback about what was difficult in the reading, what was easy and what was interesting. I can and will adjust my lectures accordingly. Your participation grade will also include my own subjective assessment of your in-class participation. There is no reason anyone should earn less than the full 10% here, so long as you engage in the learning process.

Tentative Schedule of Topics

	Date	Reading Assignment	Topic
Mon	9-Jan		Calculating probabilities
Wed	11-Jan	Talk in Portugal - No class- To be made up	Self-directed review of Probability (G&T, Ch.3)
Fri	13-Jan	Talk in Portugal - No class- To be made up	Self-directed review of Thermodynamics (G&T, Ch.2)
Mon	16-Jan	MLK Day - No class	
Wed	18-Jan	Pathria 1.1-1.3 (pp. 1-9), Handout from L&L	Counting microstates and the 2nd Law of Thermodynamics
Fri	20-Jan	Pathria 1.4 (pp. 9-16)	Enumerating the microstates of an ideal gas
TBD	TBD	Pathria 1.5-1.6 (pp. 16-22)	Gibbs paradox: counting correctly
Mon	23-Jan	Pathria 2.1-2.2 (pp. 25-30)	Phase space and ensemble theory
Wed	25-Jan	Pathria 2.3-2.5 (pp. 30-37)	Microcanonical ensembles
Fri	27-Jan	No new reading	Microcanonical ensemble examples
TBD	TBD	Pathria 3.1-3.2 (pp. 39-50)	Canonical ensembles
Mon	30-Jan	Pathria 3.3-3.4 (pp. 50-54)	Deriving thermodynamics from a canonical ensemble
Wed	1-Feb	Pathria 3.5 (pp. 54-58)	Example: classical ideal gas
Fri	3-Feb	Pathria 3.7-3.8 (pp. 61-70)	Equipartition theorem; harmonic oscillator example
Mon	6-Feb	Pathria 3.9 (pp. 70-77)	Paramagnetism
Wed	8-Feb	Pathria 3.10 (pp. 77-83)	Negative temperatures
Fri	10-Feb	Pathria 4.1-4.3 (pp. 91-98)	Grand canonical ensembles
Mon	13-Feb	Pathria 4.4 (pp. 98-103)	Examples: solid-vapor equilibrium; Einstein solid
Wed	15-Feb	Pathria 3.6, 4.5 (pp. 58-61, 103-105)	Fluctuations in the various ensembles (why does this all work?)
Fri	17-Feb	Pathria 4.6-4.7 (pp. 105-111)	Phase equilibria
Mon	20-Feb	EXAM 1 (Chapters 1-4)	
Wed	22-Feb	Pathria 5.1-5.2 (pp. 115-122)	Quantum ensemble theory
Fri	24-Feb	Pathria 5.3 (pp. 122-128)	Single particle examples
Mon	27-Feb	Pathria 5.4 (pp. 128-133)	Systems of indistinguishable particles
Wed	29-Feb	Pathria 5.5 (pp. 133-139)	Statistical interactions - two particles in a box
Fri	2-Mar	APS Meeting - No class - To be made up	
Mon	5-Mar	Spring Break	
Wed	7-Mar	Spring Break	
Fri	9-Mar	Spring Break	
Mon	12-Mar	Pathria 6.1-6.2 (pp. 141-149)	Ideal gas redux (QM ensembles)
Wed	14-Mar	Pathria 6.3 (pp. 149-152)	Statistics of the occupation numbers
Fri	12-Mar	Pathria 6.4-6.5 (pp. 152-170)	Beyond monoatomic gases
TBD	TBD	Pathria 7.1 (pp. 179-191)	Ideal gas of bosons; Bose-Einstein condensation
Mon	19-Mar	Pathria 7.2 (pp. 191-200)	Thermodynamics of BECs
Wed	21-Mar	Pathria 7.3 (pp. 200-205)	Blackbody radiation
Fri	19-Mar	Pathria 7.4 (pp. 205-212)	Phonon gas in solids
Mon	26-Mar	Pathria 8.1 (pp. 231-238)	Ideal gas of fermions
Wed	28-Mar	Pathria 8.2 (pp. 238-247)	Para- and diamagnetism
Fri	26-Mar	Pathria 8.3 (pp. 247-258)	Electron gas in metals
Mon	2-Apr	Pathria 8.4 (pp. 258-259)	Ultracold fermi gases
Wed	4-Apr	Pathria 8.5 (pp. 259-264)	White dwarf stars
Fri	2-Apr	EXAM 2 (Chapters 5-8)	
Mon	9-Apr	Pathria 6.6 (pp. 170-173)	Chemical equilibria
Wed	11-Apr	Pathria 9.1-9.2 (pp. 275-282)	The Big Bang and thermal evolution of the universe
Fri	9-Apr	Pathria 9.3-9.6 (pp. 282-290)	Particle histories
Mon	16-Apr	Pathria 9.7-9.9 (pp. 290-296)	Primordial nucleosynthesis and recombination
Wed	18-Apr	Pathria 16.1-16.2 (pp. 637-643)	Monte Carlo simulations
Fri	16-Apr	Handout	Demon algorithm and Wang-Landau density of states
Mon	23-Apr	Pathria 16.3-16.5 (pp. 643-651)	Molecular dynamics and particle simulations
Thurs	3-May	FINAL EXAM (Cumulative)	***Scheduled at 9:00 am