Physics 2541: Thermodynamics & Statistical Mechanics

Course Syllabus

Tu & Th, 9:30-10:45 in 106 Allen Hall

Course Instructor

Instructor: Andrew R. Zentner
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Office Hours: Mondays at 3PM
Thursdays at 11AM
& By Appointment

I am a member of the Department of Physics and Astronomy at the University of Pittsburgh. My research specialty is theoretical cosmology.

Please do not hesitate to contact me with **any** questions or concerns about this course. All too often, students wait until the end of the semester to express concerns, but by that time I cannot change anything. There is **no** question too insignificant and there is no need to wait until it is too late to express a concern. Of course, I have to abide by University and Department rules and I have to work within the Physics & Astronomy curriculum, so I cannot accommodate all requests, but my intention is to make this course as fun and productive as possible.

The University of Pittsburgh CourseWeb site will be the primary means of communication throughout the class. It is the responsibility of the student to check the CourseWeb site **often** for updates and assignments. I will not distribute hard copies of materials in class and I will not be responsible for pointing you to assignments on the CourseWeb site.

Office Hours

If you come to office hours for help with an assignment, please be prepared to demonstrate that you have put some effort into the problem(s). In particular, be prepared to describe your thought process and the point at which you are stuck. I will **not** help with homework problems if you cannot first describe to me how you tried to solve the problem.

Course Description

This is a course in basic Thermodynamics and Statistical Physics. The course will cover classical thermodynamics, statistical mechanics and ensemble theory including both classical and quantum statistical mechanics, approximation methods for interacting systems, and phase transitions.

Course Topics in Detail

Here is a rough outline of what will be covered in the course. This plan may be modified according to student interests, student preparation, and/or questions that may arise during the course.

- Week 1: Mathematical Preliminaries: Multivariate Calculus and Introduction to Thermodynamics
- Week 2 & 3: Classical Thermodynamics: Heat engines, entropy, thermodynamic potentials, and applications
- Week 3 & 4: Classical Statistical Physics, Phase Space, Liouville's Theorem, The Microcanonical Ensemble, Equipartition, The Classical Ideal Gas
- Week 5: The Canonical Ensemble, The Partition Function, The Virial Theorem, The Ideal Gas, Paramagnetism
- Week 6: The Grand Canonical Ensemble, The Grand Partition Function, Chemical Potentials, The Clausius-Clapeyron Equation
- Week 7: Review and Mid-Term Exam on **FEBRUARY 25, 2016**
- Week 8: Quantum Statistics and the Density Matrix
- Week 9 & 10: Simple Gases in Each Ensemble, Monatomic and Polyatomic Gases, Chemical and Kinetic Equilibria
- Week 11: Ideal Bose Systems, Bose-Einstein Condensation, Blackbody Radiation, Sound Waves
- Week 12: Ideal Fermi Systems, Degeneracy, Electrons in Metals, Diamagnetism
- Week 13: Applications: Stellar Astrophysics and the Early Universe
- Week 14: Interacting Systems: Cluster Expansion, Virial Coefficients, and Applications

- Week 15: Phase Transitions: Critical Exponents and Landau's Theory
- FINALS WEEK: **FINAL EXAM MONDAY, APRIL 25, 2016**

I intend to hold a review session prior to the final exam.

NOTE ON TOPICS: The first 12 weeks of the course represent the minimum knowledge base upon which many advanced topics are built. Therefore, I will be sure to cover these subjects in detail even if it means eliminating applications or more advanced material.

Course Grades, Homeworks, and Exams

- Homework : 50%
- Midterm Exam : 20%
- Final Exam : 30%

I will guarantee the following grades.

- A: For earning $\geq 85\%$ of possible points in the course.
- B: For earning $\geq 70\%$ of possible points in the course.
- C: For earning $\geq 55\%$ of possible points in the course.

I reserve the right to curve the course based on the performance of the students in the course, so the final grade may be higher than the guaranteed grade above.

There will be approximately 10-12 homework sets during the semester. Homework performance will constitute 50% of your grade in this course, so it will be nearly impossible to do well in this course without doing well on the homework. The mid-term exam will constitute 20% of your grade and the final will constitute 30% of your grade. Keep in mind that the final exam also determines whether or not you have passed the Preliminary Evaluation and the Comprehensive Examination in Physics.

Exams will be closed book. However you may bring two pages of handwritten notes to the exams. Make-up exams be given only under extreme circumstances.

You may discuss homework with other students; however, you must handing solutions that are your own. Any student suspected of copying homework will be warned. A second infraction will result in no credit for homework and possibly in further consequences as a result of this violation of academic integrity.

Homework must be turned in within the first 5 minutes of class on the day it is due. Late homework will be accepted for 1/2 credit up until the time that I post solutions on the

CourseWeb site. After that, late homework will not be accepted. I may post the solutions on the CourseWeb at any time without warning.

No credit will be given in either the homework or the exams for correct answers that do not give proper justification.

No credit will be given in either the homework or the exams for work that is illegible or so disorganized that it is difficult for the Instructor or Teaching Assistant to follow. This is true even if the answer is correct. It is your responsibility, and your responsibility only, to present your work in a manner that is clear, well-organized, and legible.

Textbook

Statistical Mechanics, 3rd Edition by R. K. Pathria and P. D. Beale is the required textbook for this course and is one of the standard textbooks on the subject. However, this book does not cover Thermodynamics, which will be the first few weeks of the course.

There are many useful texts on Statistical Mechanics and Thermodynamics. I find the following to be useful alternative resources.

Statistical Mechanics by Kerson Huang (this is the text used in the recent past by Professor Liu).

Thermodynamics and an Introduction to Thermostatistics by Herbert Callen (this book gives a lengthy exposition of Thermodynamics which may be useful during the first few weeks of the course and which distinguishes it from most other standard graduate texts on the subject).

Students with Disabilities

If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services, 140 William Pitt Union, (412) 648-78901(412) 383-7355 (TTY), as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course.