Thermal Physics

Physics 306: Spring 2022

Course Organization

- Overview of course content
- Instructor
- Schedule and Format
  - Lectures, lecture notes, and recordings
  - Homework submitted online
  - Midterm and final exams
  - Office hours
  - Technical requirements
- Grade Determination
- The Book and Resources
- Other Items
  - Required email communication
  - Student Accessibility Support Center, Academic Integrity, and Critical Incidents

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Overview and Learning Objectives

This is a one semester undergraduate course in thermodynamics and statistical mechanics. Statistical Mechanics is probably the most difficult, and most interdisciplinary courses in the undergraduate (and graduate) curriculum. It starts with *all* of physics, and combines this starting point with challenging concepts (at least for me) to make predictions about real things.

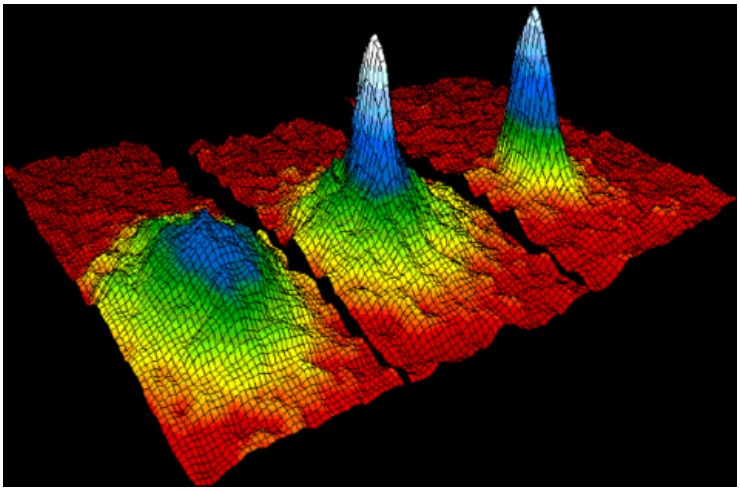
The structure and tentative order of the course will follow (but not slavishly) our excellent text book by Blundell and Blundell, see below. We will also draw examples from Daniel Schroeder's (also excellent) book, see below and Zemansky and Dittman's 7th edition of the 1937 classic textbook on thermodynamics, see below. Lecture notes of what is discussed in class will be provided. Weekly homeworks will be assigned.

1. **Preliminaries**
   - Basic Combinatorics and the Stirling Approximation: Chapter 1
   - Heat: Chapter 2
   - Probability Distributions: Chapter 3
   - Temperature and the Boltzmann Factor: Chapter 4
2. **Kinetics of ideal gasses**
   - Boltzmann velocity distribution: Chapter 5
   - Ideal gas law: Chapter 6
   - Flux through a hole: Chapter 7
   - Cross sections and the mean free path: Chapter 8
3. **Basic Thermodynamics**
   - The first law, heat capacity, isothermal and adiabatic expansions: Chapters 11, 12
   - The second law: Chapters 13, 14
   - Thermodynamic potentials: Chapter 16
   - Rods and Magnets: Chapter 17

4. **Basic Statistical Mechanics**
   - Partition Functions: Chapter 20
   - Partition Function of Ideal Gas: Chapter 21
   - The equipartition theorem: Chapter 19
   - Black Body Radiation: Chapter 23
5. **Chemical potential**
   - The grand partition function: Chapter 22
   - Chemical thermodynamics: Chapter 22 and Schroeder 5
6. **Quantum Gasses**
   - Fermi and Bose Distributions 29
   - The Fermi Gas: Chapter 30 and Schroeder 7
   - The Bose Gas: Chapter 30 and Schroeder 7

The goal of this course is for you to be able to solve physics problems associated with these topics. The homeworks are designed to help you achieve this goal.

The image below shows the velocity-distributions for a gas of rubidium atoms, indicating the formation a Bose-Einstein condensate. For this and related experiments, Eric Cornell, Carl Weinman, Wolfgang Ketterle received the 2001 Nobel Prize. Left: just before the appearance of a Bose-Einstein condensate. Center: just after the appearance of the condensate. Right: after further evaporation, leaving a sample of nearly pure condensate. We will discuss Bose condensation at the end of the course.



Lecture Instructor:

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Office Hours: Physics C-134 (Nuclear Theory Common Room)

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Teaching Assistant: TBA

Schedules and Format

The course consists of lectures, homework, midterm and final exams, and office hours.

Lectures, class meetings, and recordings

The course consists of three in person lecture hours:

> Lecture Hours: TuTh 8:00-9:20 a.m. in Melville Library W4550

At the current time, everyone participating in this class, must wear a mask/face covering at all times. Any student not in compliance with this will be asked to leave the class!

Detailed lecture notes will be given.

Homework submitted online:

Homework is a significant part of the course. It will be assigned approximately weekly, and students should expect to spend approximately 10 hours a week on homework. There will be approximately 12 assignments during the semester.

Homework will be collected online through blackboard. Students will need to produce a scan (of reasonable quality) of their homework, and submit it electronically as a single pdf document. Individual jpegs are not acceptable and will not be graded. For a typical student, the program CamScanner, which can be installed on any modern phone, is a useful tool to scan handwritten pages and convert them to a single pdf document.

Homework will be accepted late, but will be penalized at 5% per day.

The final exam:

The final exam is on Tuesday, May 17th, 2022 from 8:00 A.M. -- 10:45 A.M. in our class room

The precise date for the Midterm will be established at a later time.

Office Hours:

Office hourse are in flux, the basic plan is to have them at 3:00pm on Monday in the the Nuclear Theory Common room (C134). Our TA will also hold office hours this location. You can also try to find me in my actual office C135.

Technical requirements:

> Students will need to produce a scan (of reasonable quality) of their weekly homework, and submit it electronically as a single pdf document. Individual jpegsand other formats will not be accepted. For most students, the app CamScanner, which can be installed on any modern phone, is a useful tool to scan handwritten pages and convert them to a single pdf document. This can be submitted to blackboard.

Grade Determination and Homework

The grading will be based *roughly* on the following table. I reserve the right to change these proportions (within reasonable limits) as the course progresses to provide the best overall assessment of the class as a whole. My intent of course is to follow these guidelines.

Homework	20%
Midterm Exam	40%
Final Exam	40%

The Book and Resources

The required book for the course is

Concepts in Thermal Physics by Blundell and Blundell. Features short chapters and many examples.

Some other books which I used when preparing the course are:

An Introduction to Thermal Physics by Daniel Schroeder. Good discussion of chemical concepts, but takes a long time to write down the partition function.
Heat and Thermodynamics by Zemansky and Dittman. A classic textbook, first published in 1937. As a student I especially appreciated the discussion of experiment.

Other Items

Required e-mail communication

Email to your University email account is an important way of communicating with you for this course. For most students the email address is firstname.lastname@stonybrook.edu. It is your responsibility to read your email received at this account. Material about how to set up your University email is easily available online.

Student Accessibility Support Center:

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, 128 ECC Building, (631) 632-6748, or at sasc@stonybrook.edu. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

Academic Integrity:

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology and Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at http://www.stonybrook.edu/commcms/academic_integrity/index.html

Critical Incident Management:

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Judicial Affairs any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures.Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.