Statistical Mechanics (PHYS 370) Course Syllabus

Fall 2024 v2.0

> "A theory is the more impressive the greater the simplicity of its premises, the more different kinds of things it relates, and the more extended its area of applicability. Therefore the deep impression that classical thermodynamics made upon me. It is the only physical theory of universal content which I am convinced will never be overthrown, within the framework of applicability of its basic concepts."
> – Albert Einstein [quoted by Don Howard in *Einstein: The Formative Years, 1879-1909* John Stachel (Einstein Studies, vol. 8, Birkhäuser Boston. 2000. p. 1)]

1. Introduction to Phys 370:

Although we don't tend to emphasize it in our introductory courses, thermodynamics and statistical mechanics form one of the four major perspectives on physics: mechanics, fields (mostly e&m in the undergraduate realm), quantum physics, and thermal physics. In thermal physics, thermodynamics came first historically, driven in part by the advent of steam power and the industrial revolution. Statistical mechanics came later, is still evolving, delves into the microscopic, and is more fundamental. Our text, the excellent book by Schroeder, blends the two in a contemporary approach.

Following this approach, we will fold thermodynamics and statistical mechanics together. In my view, the heart of the course lies in the methods of "stat mech", which are a mixture of pure counting (combinatorics) and modeling the microscopic dynamics of the system through the Hamiltonian or energy. This is partly because the techniques are fundamental to the modern theoretical framework of physics and partly because the techniques are new for you so the more time to work with them the better. But we will not neglect thermodynamics!

This syllabus is the latest version. But as we explore this together, expect changes.

2. Text:

Daniel Schroeder, **An Introduction to Thermal Physics**

3. Course info:

Course materials will be available online through the Courses tab on my homepage. The direct link is http://academics.hamilton.edu/physics/smajor/Courses/370.html. The latest versions will be labeled by a version number in the top right of the first page.
What will to learn?

- Basic thermodynamics - temperature, laws,
- Partition functions! The use of these to
- increased sophistication in writing up your work for others

4. Grades:

There are 5 parts to the grade:

(1) Problem sets (now 35% [30%]): Weekly problem sets will be due at the beginning of class on Thursdays (a deadline). They will usually be about 10 problems, with a mix of quicker computations and longer derivations. Occasionally there will be lighter weeks. We will have no solutions during the mid-term week.

"Success is met by starting early!" – so that there is plenty of time to ask questions and circle back to re-work problems.

Please take the preparation of your work seriously. The logic and methods employed in your solutions are more important than the correct numerical or algebraic answer. Please present your work in a clear coherent manner with plenty of explanations so your solutions are easy to follow. The grader and I will mark solutions without sufficient explanation with "Words Of Explanation" or "WOE" for short. I strongly recommend that you copy over your solutions and hand in a readable final copy. Always check that you have included units and have stated numerical results to the correct number of significant figures. See section 10 for more tips on problem sets.

Although I encourage you to work together, you must write up your own solutions and fully cite contributions to your work. For example, if you work through a calculation with a group then cite your fellow students in the group (listing their names is fine). Cite all information you find online whether this is help from Mathematica, wolfram alpha, solutions, or sources of needed information. Cite these sources with a description and a link as appropriate. Solutions that come from elsewhere and are not cited are clear cases of plagiarism and will be treated as such under the honor code.

You have three automatic extension tokens during the semester. The policy is as follows: To opt in for one of these, write me an email **before** the beginning of class on Thursday. The request can be for any reason, illness, busy, travel, etc. You then have until Monday morning at **8 AM** to complete your solutions. Submit your solutions in person by putting them outside my office or via email with **a single pdf attachment**. Otherwise (and after this extension) the score decreases by 20% per day (24 hours): the set is graded then a reduction is computed based on the number of days the work is late.

The assignments will normally be posted and distributed at least one week prior to the due date. Solutions will normally be posted Tuesday after the due date.

(2) Quizes (10% each) We'll have short in-class quizzes in September and November. The first will be on September 26. We decided to not have the November quiz. The remaining 10% will be split between your homework solutions grade and the final.

(3) Mid-term (20%): There will be one mid-term in October. This will be a closed-book exam. I will post a study guide in advance. There will be no problem set this week.

(4) Final (now 35% [30%]): Our final is scheduled for December 19, 7 - 10 PM. Please arrange your travel so that you are on campus at this time. Towards the end of the semester we will revisit the form for the final. Please schedule travel for after this date.

5. Office hours:

I will be available for questions after class on both days and Wednesday afternoons 1:30 - 5 PM (or 4). In good weather I hope to be outside on the quad outside the building. In bad weather I will be inside, probably in G052.

6. Honor Code:

The Hamilton Honor Code relies on all of us to maintain an environment of trust and honesty. I expect you to show academic integrity by adhering to the Hone Code: All submissions should be the original work of those named as authors. The use of generative AI tools (e.g., ChatGPT) is not permitted in this course. Any use of AI tools for work in this course will be considered a violation of the Honor Code and will be referred to the Honor Court.

If you have any doubts about a situation, please ask me before engaging in questionable behavior.

7. Accommodations:

Students with a documented disability needing academic adjustments or accommodations are encouraged speak with me during the first two weeks of classes. Hamilton College will make accommodations for students with properly documented disabilities. Allen Harrison in the Dean of Students Office (Elihu Root House; ext. 4021) coordinates services for students with disabilities.

8. Staying healthy

We should all be mindful about the stresses of life on the Hill. There are times that we may feel overwhelmed, anxious, or depressed. The Dean of Students Office and Counseling Center have resources available on campus to help and support:

- Counseling Center (www.hamilton.edu/offices/counselingcenter, 315-859-4340) offers individual and group therapy, peer counselors and psychiatric treatment. If you need immediate assistance, phoning the Counseling Center and selecting option 2 will connect you with a counselor, 24 hours a day, 7 days a week. Campus Safety is available 24/7 for urgent concerns at 315-859-4000.
- Associate Dean of Students for Student Support, Sarah Solomon (315-859-4600; ssolomon@hamilton.edu)
- Associate Dean of Students for Academics, Adam Van Wynsberghe (315-859-4600; avanwyns@hamilton.edu)
- Your faculty advisor, RA and Area Director in your residence hall

9. On writing up your work for others i.e. problem sets!

For full credit for your solutions you must find the correct answer **and** present your result clearly. You can receive full credit only when you show clearly what you did. If a problem on the homework is not written up properly, you may lose up to 50%. If your solutions are illegible or otherwise unacceptable, it will be returned without grading or credit.

10. Some Advice for Problem Sets:

Before attempting a problem, review your lecture notes and do the reading. This may seem obvious, but often this is done only when a difficulty is encountered.

(1) Start the problem set early! Start the problem set early! Start the problem set early!
(2) Make a clear sketch. A well drawn figure can save a tremendous amount of time.
(3) Work slowly, carefully, and thoughtfully through the problem. It is better to work slowly but get the right answer than to work faster and make unnecessary mistakes. Start your work on white board, blackboard, or scrap paper so you don't freeze trying to get every step the correct.
(4) Work with friends. It is more fun!
(5) To avoid a round-off error, do not round numbers early in the calculations.
(6) Make use of spreadsheets - it will save time, prevent round off error and make it easy to adjust parameters. Start off with building a template with all relevant constants, Fahrenheit to Celsius to Kelvin conversions, etc.
(7) Use a reasonable number of significant digits in your answer, usually no more than 3. More digits does not make a result more accurate.
(8) In setting up longer problems express physical quantities in terms of dimensionless variables, e.g. let $t = T/T_D$.
(9) Attend office hours! Attend office hours! Attend office hours!
(10) Collaborate but write up your own solutions *this includes Mathematica code*
(11) Celebrate you final answers with a box.

(12) Check your final answers: Do they make sense? A simple dimensional analysis can catch a big mistake. Question numeric answers.
(13) Write out final copy from your solution notes. If you make a mistake at the end or a problem, don't erase what you did before or rewrite everything. Just cross out or mark what you found to be wrong and continue with a correct solution. (This shows the grader that you checked what you had done.)
(14) Present the answer in the form asked for. For example, if a force (which as you know is a vector quantity) is asked for, do not just give the magnitude.
(15) Carl Weiman (Nobel Prize - you find the date, you obtain a bonus point on homework!) advises to make sure that every solution to more involved problems include the important features (e.g. the quantization of the energy of a photon), determination of what information is required, planning of the solution process, and evaluation of the potential solution(s).
(16) Write down clearly and unambiguously with whom you worked on the problem and any resources you consulted.
(17) Build a top notch, easy to access set of records for the course - notes, problem sets, and corrected solutions. They may turn out to be an invaluable resource for you in the future...

11. Schedule

We will follow Schroeder's presentation until section 4.2 when we skip ahead to chapter 5. We will also skip 5.3 - 5.6, initially which allows us to use partition functions, starting in chapter 6, for the remainder of the semester. Depending on time and interest we will cover phase transitions, a generalization of the ideal gas law, and more realistic heat engines later in the semester.

Enjoy!

Seth Major
Science G052
x4919
smajor@hamilton.edu