

Physics 4153: Statistical Physics & Thermodynamics

Syllabus and Course Information

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*... it's so simple,
sublimely simple.
If you learn not just to see but to observe.
Put your brain to work, not just the optic nerve
If you put your mind to use,
You will find the most abstruse
Becomes so simple ...*
—Sherlock Holmes, in **Baker Street: A Musical**

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1 READ.ME

Welcome to Physics 4153. This syllabus contains everything you need to know about the mechanics of the course. So even if you've worked with me before, *read this syllabus carefully and keep it handy the semester*. If you have questions about any aspect of the course, ask me!

2 About Physics 4153

No matter what area of physics you decide to pursue in your career and personal interests, you will use thermodynamics and statistical mechanics. These two subjects, which collectively people call **thermal physics**, are intimately related in lots of fascinating ways. The importance and enormous applicability of thermo and stat mech arises from their fundamental nature: the ideas and tools of thermal physics are our keys to understanding (qualitatively and quantitatively) the properties and behavior of systems that contain a *lot* of particles—that is, almost all systems in nature.

Physics 4153 has two primary goals. First, this course will to help you understand the concepts of thermal physics and their implications for matter. Second, this course will help you master the powerful tools thermal physics provides for the study of matter. Moreover, by exploring the *relationship* between the two components of thermal physics—thermodynamics and statistical mechanics—you will come to understand how the **macroscopic properties** of systems with lots of particles, properties such as temperature, are related to the **microscopic properties** of the atoms and molecules that comprise such systems. Thus this course will bring together and clarify your understanding of both classical and quantum physics. At the same time, it will give you tools you will use throughout your career to investigate an enormous variety of physical systems and processes.

3 Prerequisites

1. Physics prerequisites

- Classical mechanics, electricity and magnetism, and the physics and mathematics of waves—all at the freshman-sophomore level.
- Thermodynamics and the kinetic theory of gases (see App. H) at the freshman-sophomore level.
- *Very* elementary quantum physics (see App. B).

2. Mathematics prerequisites

- Taylor series (see App. A).
- Differentials and partial differentiation (see App. E).
- Logarithms.
- Elementary probability and combinatorics (permutations and combinations) (see App. D).

- How to solve *very* simple differential equations (see App. F).

4 How the course works

4.1 The text

Our text is *Statistical and Thermal Physics*, by Michael D. Sturge.¹ I'll announce reading assignments from this book in class. If you're ever unsure what you should be reading, just check the home page of our **Blackboard BB** web site (see Sec. 6 below). To see future reading assignments, check the BB Course Calendar. *You are responsible for all material in the assigned reading except topics that I explicitly exclude in class. You are also responsible for material from lecture and in-class activities, some of which will go beyond the text.*

This text offers several features you need to know about:

- Even more than in other fields of physics, in thermo and stat mech it's vital to know when equations should *not* be used. Sturge is very careful to explain conditions under which results and equations do and do not apply. Pay close attention to these caveats.
- At the back of the book, Sturge includes several useful appendixes, a glossary, a list of symbols, and an excellent index. Look over these items *now*, so you'll know what's in them, and use them as you work with the book.
- Pay close attention to the examples in each chapter. Almost all of Sturge's examples involve more than merely plugging numbers into equations. Not only do his examples illustrate key physical reasoning and problem-solving techniques, they often introduce important new terminology and physical ideas.
- Sturge uses SI units, which is fine. Unfortunately, he makes the unconventional (but consistent) choice to use the unit of **kilomoles** rather than moles. This choice changes (by three orders of magnitude!) the values several constants you learned in freshman physics.² Such differences shouldn't give you any trouble, *but if you don't pay attention to them, many of your numerical answers will be off by three orders of magnitude!*

4.2 WarmUps

Prior to our first day on each reading assignment, you'll take a WarmUp. A **WarmUp** is a short (five questions) on-line mini-quiz that covers the assigned reading. WarmUp questions are very easy *if you have read the assigned material attentively and thoughtfully*. WarmUps offer you an easy way to earn essentially **free points**. *On the WarmUps, you need not give the right answer to get full credit*. Rather, you will earn full credit you *if* you make *serious* effort to answer each question and if your answers demonstrate that you have read the material.

Each **WarmUp** is available on-line through out BB site. *You must submit the completed WarmUp through this site before 8:00 PM on the due date.*³ Except when I announce otherwise, there will be a WarmUp every Monday night. I'll post each WarmUp several days in advance, so you can take it at any time that is convenient for you. *Shortly after 8 PM on the due date, the BB system will automatically disable the WarmUp. After which time it will be inaccessible to you or to me.*⁴

4.3 Question-and-Answer forms.

Like all topics in physics, ours is rich with concepts, new ways of thinking about nature, problem-solving strategies, and so forth. As in all courses, we have nowhere near enough time to cover all this stuff during our class meetings. *So we will focus in class on what **you** need to help you master the material.*

¹We won't cover everything in this book. From time to time, I'll supplement the text with additional material.

²For instance, you probably learned Avogadro's number as $N_A = 6.0 \times 10^{23}$ particles/mole. In Sturge, $N_A = 6.0 \times 10^{26}$ particles/kmole.

³If you check your grades online immediately after taking a WarmUp, you'll see a zero. Don't panic. Blackboard won't automatically grade the questions. I do that. Your score will show up early on the day after the due date.

⁴If something goes wrong while you're taking a WarmUp (power outage, nuclear holocaust), don't panic. Send me EMAIL immediately. *If I get your EMAIL before the system disables the WarmUp, I can reset the system so you can complete the WarmUp. After 8 PM, however, I can't do anything for you.*

The only way I can possibly know what you need is if you tell me. So a vital part of our class meetings will be a round-table **question-and-answer (Q&A) session** on the first day of each new topic. These sessions have two goals. First, we need to determine what material (if any) in the assigned reading is giving you trouble, so we can deal with that material before we leave the topic. Second, we need to determine what topics in the assigned reading are most important. I will ensure that we accomplish the second goal. But to ensure that we accomplish the first goal, the class need your input.

The primary mechanism for our Q&A sessions is the **Q&A form**. You can download copies of this one-page form from our BB site. *As you study each reading assignment, keep a Q&A form by your side and jot down on it comments and questions. Bring the completed form to class on our first day on the assigned reading.* You will refer to your completed form during our discussion, and I'll collect the forms after we're through, so you'll get credit for having filled it out.

4.4 Lectures, workshops and other in-class activities

As you have doubtless deduced, Phys 4153 isn't your usual "lecture course." To achieve the goal of using class time to help you master the material, we'll engage in a variety of activities. In addition to the Q&A session, we'll frequently do in-class workshops (in small groups) and other activities. I'll frequently talk through the solution of problems, in order to clarify problem-solving strategies and illustrate how to think about this subject. And from time to time, I'll give short "mini-lectures." I'll give a mini-lecture under the following circumstances.

- to provide an overview of each major topic and how it fits into the "big picture" we're constructing;
- whenever several students identify a topic with which they're having trouble;
- to clarify a topic that our text does not adequately cover;
- to supplement the text.

Your regular participation in every class period is vital, not only to your understanding of the material, but also to the understanding of others in the class. Consequently you must come to every class, and in-class participation forms a significant part of your grade (see Sec. 7.2 below).

4.4.1 Class Notes

Students often ask me whether they should take notes in class. **The answer is yes!** You are responsible for material in the assigned reading and for everything we do in class. Material from mini-lectures, in-class activities, and other things we do during class *will* show up on tests. So you *definitely* need to make notes during lecture and after in-class activities.

4.5 Self-assessment tests.

The only way to know whether you have mastered a topic is to test yourself. In this class, the tool we use to assess your mastery of key topics and concepts is the **Self-Assessment Test (SAT)**. Each SAT is designed to help you assess your mastery of the most important material we have covered. Typically, an SAT will contain both questions and problem. **Questions** will be basic, straightforward, and oriented towards definitions and concepts. **Problems** will be brief, focused on key skills, and *heavily* based on homework and in-class activities. *You will be responsible for material from in-class activities, lectures, homework, and test.*

SATs are in-class, closed-book, closed-notes. However, you may bring one card (no larger than 5 in \times 8 in) with anything *handwritten* on it. (You may *not* Xerox or otherwise photo-reduce stuff to put on this card.) You must hand in your card along with your completed test.

4.5.1 SAT and final-exam dates

I'll announce the content of each SAT (and the Final) well in advance of its date. You can also find up-to-date information on the Blackboard "Course Calendar." Mark the following dates on your calendar *now*:

1. **SAT 1: Thursday September 23, 2004.**
2. **SAT 2: Thursday October 21, 2004.**
3. **SAT 3: Thursday November 23, 2004.**
4. **Final Exam: Tuesday December 14, 2004 (8:00–10:00 AM) [comprehensive].**

4.5.2 The EarnBack

After I return an SAT you can earn back up to $\frac{1}{3}$ of the total number of points you lost! To earn back these points, all you have to do is write up a short but thorough discussion of each question on which you want more credit. Your discussion must include the correct answer—in your own words, including a brief explanation and discussion of the answer—and a specific reference to where in the text, lecture notes, etc. you found the information you used to get your answer. *The number of points you earn back will depend on the thoroughness and accuracy of your discussion.* (“Thorough” does not mean long; “thorough” means that you include all the key points and link them together clearly.) While you are planning your EarnBack, you may discuss the questions with other class members. *But you must write your EarnBack submission entirely by yourself—that is, your EarnBack submission must be **entirely** your own work.* To receive your bonus points, write up your submission and give it to me *along with your graded test*, within one week after I return the graded SAT. Write your EarnBack on one side of the page only.⁵

5 Homework.

5.1 Important ground rules for homework.

- Homework assignments are due on the assigned date no later than 5 PM. (Most homework will be due on Thursdays.) To determine the due date of a particular assignment, check the home page (or Course Calendar) in BB. You may either give your homework to me in class or put it in my mailbox in the Physics Department office. *You are responsible for ensuring that your homework winds up either in my hands or in my mailbox no later than 5 PM on the posted due date.*
- Homework assignments will be posted on BB at least a week prior to their due date. At the suggestion of students in previous semesters, no homework will be due during a week of an SAT.
- I strongly encourage you to work together on homework and to discuss the problems with me and/or others in the class. *But the solutions you hand in must be your own. Your solution to each problem must be your individual discussion and presentation of the problem, expressed entirely in your own words. Use of anyone else’s solutions (mine, other students’, other physicists’, your mom’s)—from any source—constitutes plagiarism (academic misconduct) and will be prosecuted as such.*
- Write your solutions *neatly* on one side of the page only. Clearly number each solution with the number of the problem on the assignment *and*, if the problem came from the text, its number in the book.
- *The solutions you hand in must be reasonably neat, clear, and complete. Never submit “scratch work.”* You are responsible for preparing solutions that are clear enough and contain enough detail that we can figure out what you were doing and why. Neither I nor the grader can read your mind, and it’s not our responsibility to deduce what you were thinking when you worked the problem. Include discussion to clarify how you were thinking about the problem. A well-presented problem will ensure maximum partial credit, even if your answer is wrong. A poorly presented answer without discussion will ensure almost no credit, even if your answer is right. Homework that fails to meet these criteria will be returned ungraded and will receive no credit.
- A well-presented solution must contain *at least* the following elements:
 - A **brief summary** in your own words of the problem. Clearly state what the problem asks you to do. If appropriate, include sketches to clarify the problem.
 - A **brief statement of the physical principles** you’re going to use to solve the problem and whatever assumptions or approximations you will make.
 - A **logical presentation** of your solution, including details and brief comments that explain what you’re doing and why. Define clearly any symbols you introduce, either in words or in a figure.
 - **The answer.** When you get an answer, don’t just put a box around it and rush on the next problem. Do two additional things:

⁵Extra credit problems on tests are not available for EarnBack credit.

- * **If your answer is a number**, be sure that you have included whatever units are appropriate and that you have given *only* the appropriate number of significant figures. **If your answer is a graph**, be sure all axes are labeled (with units) and that curves or points are clearly labeled.
- * *Think about your answer!* Ask yourself questions like, Does your answer make sense? **If your answer is an equation**, is it dimensionally correct? Does it behave correctly in limiting cases where you know the right answer? **If your answer is a number**, are its units correct? Is it sensible—roughly of the right order of magnitude and with the sign you expect?

- *Homework not handed in by 5 PM on the designated due date will not be accepted for credit.*

5.2 Friendly advice.

I strongly urge you to follow these guidelines in approaching the homework. Doing so will maximize the benefit you get from the effort you invest. As a bonus, it will ensure that your work will be as efficient and enjoyable as possible.

- *Read the problems as soon as the assignment is posted.* Do this even if you haven't yet read the relevant sections of the text. Don't try to *work* the problems at this stage: just plant them in your mind. Your mind will work away on them while you study and discuss the material.
- *Discuss and work on problems together.*
- *Don't procrastinate.* Compared to problems in other courses, the exercises and problems we'll work require only very simple math. But these problems are not trivial: *most problems require time for thought, brainstorming, and discussion.* If you start the homework the night before it's due, then you'll put yourself under a lot of needless pressure and certainly won't learn much.
- *Don't be reluctant to ask questions.* If you don't understand a problem, are having trouble getting started on a problem, or just want to talk about it, seek help! Contact another class member. Raise your question during class. Come see me. Send me EMAIL. Remember: *helping you is my job.*
- *Hints and Answers.* If several of you ask about a problem, I'll post a hint and/or answer on our BB site.

6 Physics 4153 and the Internet.

6.1 Blackboard (BB)

Much of the course content (including WarmUps, homework and reading assignments, information about assigned problems) will be available on our BB web page at <http://ou.blackboard.com>. **You must set your browser settings correctly for BB or it won't work! Do this immediately!** To find out how, surf to the AskIt Information Technology web site (<http://askit.ou.edu>). Under "Category" choose "Blackboard." Then under "Select Subcategory" choose "Getting Started." Follow the links to find out how to set your browser and how to log on. You'll find other useful information under "Blackboard for Students."

Once you successfully log onto our BB site, wander around. Find out how you can use BB to check your grades at any time. Check out the Course Map. Visit "Student Tools," and pay special attention to the Calendar, where you can always find a regularly updated schedule of what we'll be doing, when stuff is due, test dates, etc. Look under "Communication," where you can send EMAIL to me or others in the class. Especially important is the "Assignments" section; that's where I'll post homework, study guides, notes, and other useful stuff. Finally, check out "Course Information," which contains this document, the course outline, and other administrative stuff.⁶ And note that you can use Blackboard at any time to see your current grades.⁷

⁶You can customize BB and use it in lots of personalized ways no one else in the course (including me) can access. To learn how, go to "Student Tools" and click on "Manual" to get the on-line help.

⁷Blackboard reports something it calls "total number of points." *Pay no attention to this number.* Blackboard assumes that all activities (homework, tests, etc.) are weighted equally; that's not true in this course, as described in the section on Grades in this syllabus, so Blackboard's *totals* don't mean anything.

6.2 EMAIL

Never hesitate to send me questions about any aspect of the course via EMAIL. I check my EMAIL daily (when I'm in town) and reply to student questions as soon as possible. If your question is pretty technical (e.g., involves equations, figures, tables or other material that's hard to type as text), I'll probably ask you to stop by my office. If my office hours aren't convenient for you or you want to talk sooner, let me know via EMAIL or phone, and we'll arrange a mutually convenient time.

6.3 Useful free software

Most of the stuff I'll post on BB will be PDF (portable document format) files. *To read and/or print these documents, you must install the Adobe Acrobat Reader (Version 5) on the PC you're using.* Acrobat is one of several free software programs you might want to download and install on your browser. You can find such software by following the **Useful Free Software** link on the Links section of our course web site. There you'll also find links to the latest versions of Netscape Communicator and Internet Explorer, as well as MathReader, WinZip and other useful software. Most of this stuff is optional, but *you must have Acrobat Reader installed and working from day 1.*

6.4 Other resources

From my web page you can access resources that might prove useful in this (or other) courses. To get there, go to the home page for the Physics Department (www.nhn.ou.edu), click on **Faculty**, find my name in the list, and click on the corresponding link. Once at my site, follow the links at the top of my home page to find annotated lists of internet sites that contain useful information about *Mathematica*, L^AT_EX, physics, etc. Follow the *Mathematica* link to view or download the latest versions of my “*Mathematica* Tips, Tricks, and Techniques” and one-page “Do and Don't” sheets.

7 FAQ

7.1 Class meetings.

7.1.1 Is it OK if I come a little late?

No. My classes start on time and stop on time. I will never ask you to stay beyond the official end-of-class time (11:45), because I think doing so is discourteous.⁸ Therefore, we will begin *every* class at the official start-of-class time (10:30)—not five minutes later, not 10 minutes later. If you come late, you will disrupt the concentration of everyone in the class, which is a severe discourtesy to the whole class. *So, barring a real emergency, you should arrive at every class meeting in time for us to begin at 10:30.*

7.1.2 How should I prepare for each topic?

Before coming to class, read the assigned material and work the on-line WarmUp. Don't skim! Read and think about what you're reading! Take notes! As you read and ponder, jot down question on the Q&A form.

7.1.3 What should I bring to class?

In class we will frequently work with our textbook. **So bring your text with you to every class.** You should also bring a hand calculator and paper to take notes and to work in-class activities. ***DO NOT bring anything that might disturb or distract others in the class. No food, no newspapers or magazines, no boom boxes, no pets, etc. Turn off or pulverize your cell phone!***

7.2 Tests and grades and all that.

7.2.1 Do all the Self-Assessment Tests count the same?

No. In order to help you maximize your grade (and cut you some slack in case you have an off-day), your lowest grade (of three) will count less than the other two grades.

⁸However, I will always be happy to hang around after class to talk with anyone in the class who wants to talk.

7.2.2 Do you give make-up tests?

Nope. If you absolutely cannot attend class on the day of a scheduled SAT, contact me *before that date*, and we'll discuss other arrangements, if appropriate.

7.2.3 What do I do if I think a problem has been graded incorrectly?

If at *any* time you have a question or a complaint concerning the grading of a homework or test question, bring it to my attention. I would be happy to reconsider the grading. **If your question is on a test question**, ask me about it. **If your question is on a homework problem**, you should first contact the grader. Since the grader graded the problem, he or she is most likely to be able to help you. If, after talking with the grader, you're still concerned about a homework question, though, ask me about it.

To keep the paperwork under control, I ask that you proceed as follows. *Write me a note in which you explain in detail why you think the problem was incorrectly graded, then give the note and your graded solution to me or put it in my mailbox.* I'll take care of it and return it to you as soon as I can.

7.3 Grades.

7.3.1 How much does each activity contribute to my final grade?

Contribution	Percentage
Workshops & other in-class activities	10
WarmUps	10
SAT: Highest Score	15
SAT: Second Highest Score	15
SAT: Lowest Score	10
Homework	20
Final Exam	20

7.3.2 How are workshops graded?

Note that participation is an appreciable part of your grade. The good news is that *you earn credit for an in-class activity by participating in the activity.* For example, for each **workshop**, I will collect your group's solution and will assign points on the following scale:

1. If you were present and your group made substantial progress on the workshop, you earn **3 points**;
2. If you were present and your group made very little progress on the workshop, you earn **2 points**;
3. If you were **absent**, you "earn" **-3 points**.

7.3.3 Do you curve grades?

Nope. Curves force a unique group of individuals to fit essentially arbitrary statistics that never apply to small-to-intermediate size groups. If everyone gets an A, that's great! Moreover, *you're not in competition with one another in this course.* Your grade is your own to earn, independent of how well anyone else does.

7.3.4 What's the grade scale?

Your grade will not depend in any way on that of anyone else in the class. You can't possibly hurt your grade by helping your fellow class members. In fact, I guarantee that by doing so you'll *improve* your grade. Everyone in the class can—and, I hope, will—earn an A.

Provisional Grade Scale

93–100	A
76–92	B
50–75	C
35–49	D

Note that you can't get an A if you don't do the WarmUps. You can't get an A if you don't participate in class. You can't get an A if you don't do the homework. You can't get a B if you neglect any two (or, worse, all three) of these items.

7.4 Miscellaneous.

7.4.1 How can I find out about corrections to handouts and late-breaking course news?

Check the home page of our BB site every day! On that page, I'll regularly post any corrections to course materials, revisions in the schedule, tips and hints on the homework, etc. Remember that on BB you can also find current and future homework due dates, reading assignments, WarmUp dates, and info about what we're going to do during the week.

7.4.2 When are your office hours?

I'll announce office hours in about a week. *During office hours, you have top priority.*

7.4.3 Can I get help outside of office hours?

Definitely! At times other than office hours, I have a flexible open-door drop-by policy for everyone: at any time *Monday through Thursday* that I'm in my office, the door is open, and no one is already talking to me, you are welcome to stop by. (On Friday, students in my research group have priority.) If you want to find out whether I'm in my office and available, feel free to call. In addition, you can always get help via EMAIL.

7.4.4 How can I contact you if I can't stop by?

If you can't find me, don't waste your time looking. Leave a voice-mail message or send EMAIL telling me when you'll be free. We'll set up a time to meet.

7.4.5 I missed class. Where can I get handouts or graded work you returned?

There is a metal rack immediately outside the door of my office. That's where I put anything not picked up during class. It is *your* responsibility to retrieve your stuff before the end of the semester—at which time it will miraculously migrate to a trash can, never to be seen again. **IMPORTANT NOTE: If for some reason you absolutely cannot get to a class, be sure to meet soon with someone who was present to get detailed information about what we did during the class you missed.**

7.4.6 I have an academic disability. What do I do?

If you have a disability that may prevent your from fully demonstrating your abilities, please contact me personally as soon as possible so that we can discuss accommodations necessary to ensure your full participation in this class.

7.4.7 Can I bring my cell phone and are pager to class?

Cell phones and pagers ringing in class is *extremely* distracting to others who are trying to pay attention. *So leave it at home or turn it off before class!* Violators will be confiscated!

8 Feedback

I want you to let me know what you think about this course. *Only with your frequent, honest, constructive feedback can I make this course work for you.* In particular, I need to know what, if anything, you need from the course or from me that you're not getting. I will occasionally ask you to fill out anonymous on-line surveys about the course. But please don't wait for these surveys to provide feedback.