Syllabus - *Last edit* *Sep 22, 2025*

PHYS303 - Statistical Physics, Fall 2025

(aka Thermal Physics, Statistical Mechanics, Thermodynamics)

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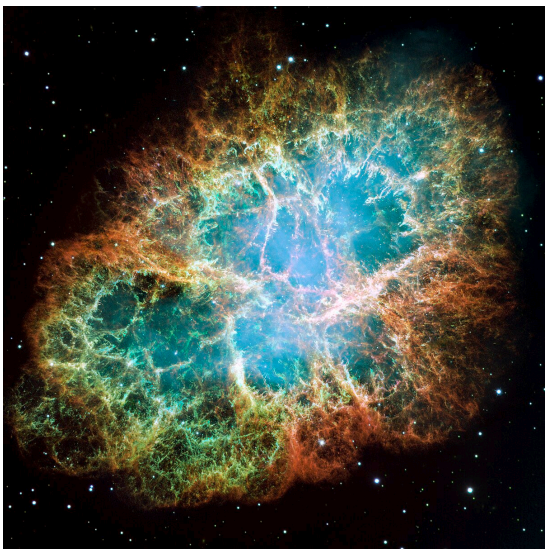


Image: The Crab Nebula. Because it's beautiful and also because concepts in Statistical Physics are used to explain the different emission features (shown by different colors) as a function of temperature and density of the atoms in the cloud.

Logistics

MWF 9.30-10.30am TBC **Student drop-in hours THURSDAY 11.30-1.30pm Observatory Classroom.**	Karen Masters Office: Observatory A Email: klmasters@haverford.edu

Overview

Statistical Physics (sometimes Statistical Mechanics) is often not well understood as a topic to beginning physics students, but ends up containing many people's favorite undergraduate physics content. It was mine! Statistical physics combines ideas from the fields of quantum mechanics, classical mechanics, probability theory, and relativity, to name a few. It connects macroscopic, bulk properties (like

temperature) to properties on a microscopic scale (like particle velocities). It is subtle and complex, and it cannot be learned by simply doing problem sets. You will need to read (books and online) talk to your classmates and to me (and anyone else who may be interested). You will directly benefit from every minute spent synthesizing the material. The more connections you make, the more likely you will fall in love with statistical mechanics. Applications range from solid state physics, to astrophysics, to information theory, to engines, to non-linear dynamics, to thunder, biological systems, climate change, etc. etc.

There is no way to be bored in this class once you find the reason that statistical physics is important to your interests in physics or astrophysics. It's used in an astonishing array of applications of physics.

This course is not for the faint of heart! It may be difficult and time consuming at times. However, by the end of the semester, you will have a newfound appreciation for our Universe and this understanding will be a beautiful addition to your physics education.

Textbook

Concepts in Thermal Physics, 2nd Ed., by Stephen J Blundell & Katherine M Blundell

(note that the edition is important, as there were some fairly big changes from the 1st edition).

Moodle Use

This class will make use of Moodle. Assignments, any additional course information, videos, collective notes, etc. will be posted there. Please check it regularly.

Gradescope

This class will use a tool called "Gradescope" to collect assignments which will be turned in (as scanned PDFs). We will have a practice assignment the first week of class.

Slack Workspace

This course will make use of a Slack channel in the Dept. of Physics & Astronomy Slack workspace. If you are not already in the Slack workspace please reach out for an invite link.

Slack can be accessed simply using a website if you like, but it also has an app (for various phones/desktops) you can download. I find the app useful since you can get notifications when there's a new post. You can also set up to get emailed when you have Slack notifications. And you can also send private, direct messages using this platform. This is my preferred mode for quick communication.

Schedule

The aim of this class is for you to learn statistical mechanics and thermodynamics to your bones. The list of topics in the Schedule serve as a general outline for the course. As the semester progresses, it might make more sense to reorganize, add or omit various topics. I hope we will have time to cover some "Advanced Topics" as well! In the last few days of classes, you will each (likely in groups) teach a topic of your choice.

Expectations for Homework

- Don't overuse ChatGPT (or similar LLM/AI searches) unless asked to do so
- Always OK to use a Table of Integrals (refer to it)
- Usually OK to use Mathematica (but often not helpful; and say you used it).
    - Some problems with be marked as Mathematica not allowed
    - **No screenshots from Mathematica** - use it as a reference or a calculator (with credit), and then write out your answers

First draft HW (peer review and feedback submit in Gradescope):

- Graded on completion only - you have to submit something, and you have to discuss your and their solutions 1-1 with a peer in the class.

Pretty Copy (submit in Gradescope):

- You are expected to consider any feedback on the first draft version and fix any mistakes
- I expect most people will get all the answers right, so:
- Will be graded on the presentation/explanation of the answer as much as the answer:
    - You need to demonstrate your understanding of the problem solving, explain in your own words (after working on it with your group)
    - Should be able to understand the question from what you turn in as a solution (either directly including the problem, or explaining it in your own words is fine)
    - Results should be presented in a physically meaningful way (think about sensible units, number of significant figures, how numbers are presented). Reflect on the result.
- Check you actually answer all the questions in each part.
- You must also turn in your reading notes on the topic which will also get a quality grade/feedback.
    - You may include scans of pages in the book ONLY if they have significant annotations.
- For your own sake (as you can use these in exams), make both the solutions and your notes clear and legible.

Deadlines

The way the class is set up (see the weekly schedule) means we need to draw a firm deadline for turning in first reading quizzes (usually Mon morning) and first draft solutions (usually Sunday noon). If there are circumstances preventing you from meeting these deadlines, please let me know ASAP. Communication is key!

Deadlines for the pretty copy solutions are more flexible, if you request it in advance, but I urge you to keep up with the schedule or you will regret it when it comes time for the mid-term and final.

Assessment (grading)

Reading Quizzes (completion - you get one for free after that this is the fraction you submit)	5%
First draft solutions + peer discussion (completion)	15%

Pretty copy solutions + reading notes (graded mostly on quality of explanations)	30%
Engagement in class (attendance etc)	5%
Presentation of an advanced topic (graded)	5%
Exams - midterm and final (grade will be the best of the two; but you must take both)	40%

I will use the following % to 4.0-scale conversion and will aim to construct grading rubrics (for the first drafts, exams and presentations) which reflect this. I ask for your trust that grading will be done fairly to the best of my, and the graders' ability. I often drop the weakest grade when calculating averages.

- 4.0 - 94%+
- 3.7 - 90-93%
- 3.3 - 87-89%
- 3.0 - 83-86%
- 2.7 - 80-82%
- 2.3 - 77-79%
- 2.0 - 73-76%
- 1.7 - 70-72%
- 1.3 - 67-69%
- 1.0 - 63-66%

Exams

There will be a midterm (in Week 8) and a final (during Finals week). Having two exams is intended as a way to provide a lower stress experience - you can try things out in the midterm in a lower stress environment (it doesn't have to count) and if you do well you can have a low stress final.

For both exams you will be allowed to use only your Pretty Copy Solutions/Reading Notes that you build over the semester. You may not use the internet (including LLM) or discuss either exam with anyone else in the class. If you are consistent and do the work for this class, the exams should be your chance to shine!

If you take both the final and the midterm, your midterm grade will be dropped in favour of the final exam grade, unless the latter is lower - in this way your midterm result will form a baseline for the final exam grade (e.g. if you get 80% in the midterm that will be the lowest you can get for the exams, even if you completely mess up the final - if you don't do the midterm then that's on you and you get the final exam grade entered).

You must do the final - your exam grade will be the lower of your midterm result, or 80% if you do not take the final.

Presentation

At some point in the semester, you will get a chance to teach the class! You will need to prepare a lecture - this will have to be done in groups given the size of the class. Like anything else, public speaking

requires practice. You may choose a topic that interests you from the “Advanced Topics” sections or other sections we haven’t covered in class. You are encouraged to give a presentation on how statistical physics intersects with your senior thesis work or other research. More details will come closer to the end of the semester.

Getting Help

The easiest way to fail in upper level physics is not to seek out help when you need it, and to avoid seeking help if you fall behind in the schedule. I encourage the use of peer tutors, and also study-groups for peer-support in this class, and I intend to reach out early if I see you missing assignments/deadlines.

DROP IN HOURS SET: 11.30am-1.30pm (sometimes 1pm) Thursdays. Observatory Classroom.

Student drop-in hours are times I specifically set aside for you! There is no need to make an appointment. Please come and ask any questions you have. Appointments may be available with me at other times via Google Calender (book a time to meet with me), but please be aware that with such a large class, my availability may be limited.

Slack Direct Message is the best way to get in touch with me and email is a close second best.

The Office of Academic Resources (OAR) is positioned to help you navigate Haverford from customs to commencement. Our services are free and unlimited. Our office is located on the first floor of Stokes and you're welcome anytime to study, relax, caffeinate, and connect with peers and/or a kind staff committed to your success and wellbeing. We offer an array of services, workshops, academic accountability groups, themed seasonal study breaks, and other events throughout the academic year, but our two main academic support structures are:

- **Academic Coaching:** Work with a professional, or peer, coach to set goals and develop a plan for success (however you define it). We facilitate conversations to explore 'how' to do college, from balancing time management goals, managing large, or competing, projects, developing discipline-specific study strategies, such as methods to engage and balance readings, and preparing for an exam, along with much more! Trust the process.

Please visit haverford.edu/oar to learn more about us and/or schedule an appointment. We look forward to supporting you, at any point in your academic journey.

Honor Code

Collaboration is an important part of science. You are strongly encouraged to work together and/or consult one another for work in this class. You are encouraged to consult any books necessary as well as resources on the internet. You must, however, turn in your own individual assignments/project reports, and this must be written on your own. **Copying and pasting (even parts of sentences, and including from LLM) is not permitted and is a violation of the Honour Code.** Good collaboration involves everyone understanding what is going on. Therefore even if the basic solution is shared you must explain it in your own words (including mathematical words). Please list any students that you collaborated with. Please pay attention to your classmates to make sure no one is being left out of collaborative work.

Be aware that **LLM (like ChatGPT) are often wrong** in subtle details of answers they give to physics questions (and honestly more generally). They are designed to create realistic sounding answers, which are not necessarily factually correct. While I think it is fine to use tools like ChatGPT as part of your brainstorming process, and to do things like check your grammar, code, any copying directly from such tools is plagiarism (in fact arguably ChatGPT itself plagiarizes, as it does not properly credit where it obtains the information it shares) so I plan to trust that you will not do this. In some cases use of these tools will be detrimental to your learning process. **The process and struggle to think of an answer is a significant part of learning**, and while it might be more comfortable, you do yourself a disservice if you try to skip the necessary thinking.

Inclusion, Diversity, Equity and Accessibility

Our classroom should be a place where all members will be treated with respect. We welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, gender expressions, national origins, religious affiliations, sexual orientations, ability - and other visible and non-visible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class. If something was said in class (by anyone including myself) that made you feel uncomfortable, please talk to me about it (anonymous feedback is always an option - there will be a link in Moodle). I appreciate any opportunity to continue my learning about diverse perspectives.

In an ideal world, science would be objective. However, science is done by people, and is historically built on a small subset of privileged voices. In this class, we will make an effort to read work from a diverse group of scientists, but limits still exist on this diversity. I believe that integrating a diverse set of experiences is important for a more comprehensive understanding of science. We may discuss issues of diversity in physics/astrophysics as part of the course from time to time. Please contact me (in person or electronically) or submit anonymous feedback if you have any suggestions to improve the quality of the course materials.

Accommodations

I am committed to partnering with you on your academic and intellectual journey and recognize that you bring many strengths, perspectives and strategies as you navigate this journey. I encourage you to think proactively and strategically about leveraging these strengths, in partnership with the many resources on campus. These resources include CAPS (free and unlimited counseling is available), Office of Academic Resources, Writing Center, Student Diversity Equity and Access Team, Health Services, Professional Health Advocate, Religious and Spiritual Life, the GRASE Center, and the Advising Deans. At times you may experience challenges or stressors that impact your ability to fully engage intellectually. If the stressors are academic, I welcome the opportunity to discuss and address those stressors with you in order to find solutions together. If you are experiencing challenges or questions related to emotional health, finances, physical health, relationships, learning strategies or differences, or other related topics, I hope you will consider reaching out to the many resources here on campus. Additional information can be found at https://www.haverford.edu/deans-office-student-life/offices-resources.

Additionally, Haverford College is committed to creating a learning environment that meets the needs of its diverse student body and provides equitable access to students with disabilities. If you have (or think you may have) a disability related to mental health, chronic health, neurological state, and/or physical condition – please contact the Office of Access and Disability Services (ADS) at hc-ads@haverford.edu. It is never too late to request ADA accommodations – our bodies and circumstances are continuously changing. Please know that all inquiries and health-related information is handled in a sensitive and confidential manner.

Students who have already been approved to receive academic ADA accommodations and want to use these in this course should share their accommodation letter and make arrangements to meet with me as soon as possible to discuss how their accommodations will be implemented in this course. Please note that accommodations are not retroactive and require advance notice in order to successfully implement.

If, at any point in the semester, a disability or personal circumstances affect your learning in this course, please do not hesitate to reach out to me. I want to be sure you are aware of the full range of resources and options available to you.

It is a state law in Pennsylvania that individuals must be given advance notice that they may be recorded. Therefore, any student who has a disability-related need to audio record this class must first be approved for this ADA accommodation by Access and Disability Services and then must communicate approval to me. I will then make a general announcement to the class that audio recording may occur while respecting students' right to privacy by not identifying the individual(s).

PHYS303 - description of weekly schedule

Last edited Nov 11, 2025

PHYS303 - description of weekly schedule
- Mondays - New topic
- Wednesdays - Problem Solving
- Fridays - Review, Cement Learning and Finish First Draft Solutions

Topic Schedule - PHYS 303 - Fall 2025

A “normal” week in the semester will follow the below schedule, but sometimes it will be compressed into a two day week, so sometimes we will do “Monday” on “Wednesday” etc.

Mondays - New topic

Before Class:

***Reading*:** It is required that you *read* the chapter before class and *take notes*! As you read, take the time to stop and think, what does this mean? Do I really understand this step? Could I explain it to my classmates if they are confused? This reading should be your main focus before class. TAKE NOTES! You will turn in your notes with your final problem set for this topic.

***Reading Quiz*:** On Moodle there is a quiz with simple questions asking you for a comment and a question about the reading. These will close (I will record completion) ~1 hour before class and will help guide how I conduct the class.

In Class:

***Instructor Context*:** I will not give a lecture that repeats what is in the book. I will usually give a brief summary in class, and address common comments/questions from the reading. The purpose of this is to place the topics covered in the reading in a big picture context.

Last week’s Problem Review: Monday classes may include a review of selected draft solutions from last week’s problem set. For a random selection of problems, I will select a solution (or two) to review “in front of the class”. This may sometimes be a “posted video” rather than live in class.

Wednesdays - Problem Solving

Before Class:

***Problem Sets*:** Each week’s readings has an associated problem set listed under PROBLEMS in the Schedule. Try to look them over, think about them and jot down a framework for solving each problem before Wednesday class.

In Class:

***Problem Set Discussion*:** We will have breakout groups where you can discuss problem solving strategies. I will assign a "presenter" to one person in each group. When the full class reconvenes on Friday the presenters should be ready to summarize their group's thoughts and then the full class will discuss the proposed strategies. There is no single way to solve many of the problems in this class!

Fridays - Review, Cement Learning and Finish First Draft Solutions

Before Class:

Self reflection on Understanding Quiz: There will be a Moodle quiz asking for your self reflection on how well you understand the topic this week due 1 hour before the Friday class. I will use these to pick up on specific topics to review in class.

In Class:

***Problem Set Presentation*:** Presenters from Wednesday class will summarize their group's thoughts with a different problem solving group (and sometimes the entire class).

In/shortly after Class:

***Complete First Draft Solutions*:** A first draft of your solutions will be due shortly after class discussion. You must work in pairs to discuss these and exchange feedback before submitting. On most Fridays there will be time in class to work on first draft solutions, and in some cases complete this peer review. Please submit your draft copy after peer discussion (typically **noon the day before the next class**). As well as submitting your draft, you will provide comments on how peer review went, and select the question you most want reviewed in class. These will not be graded except for completion (both draft+review/discussion).

***Video/In-class Feedback*:** For selected problems, I will review a first draft solution (or two) "in front of the class". This may be a mixture of live class time, and "posted video".

***Pretty Copy Solutions*:** Once you have strategized each problem on your own, discussed in class, submitted a first draft, received feedback from peer review, and potentially seen a review of the problem in class you should feel like you understand every step of each problem very well. On your own, you now write a **Pretty Copy** of each of your solutions. In this you must show all steps, explain all steps, reference equations used, and put it in context. You will also include your reading notes, to generate your own very clear packet of content and problem solving for this topic. These will be graded mostly on the quality of the explanation of the problem (since I expect most of you will get 100% of these correct).

Pretty Copy Solutions will be **due in Gradescope one week after the first draft**. This due date will be marked clearly on Moodle. This step is important since ***you will have access to only these for the final and midterm.***

Topic Schedule - PHYS 303 - Fall 2025

WK	Meeting Date	Due Dates (Draft/Final)	Topic	Reading	Problems (Numbering from 2nd Edition)
Preliminaries (Part I)					
1	Wed 3rd Sep		Introduction to the class		
	Fri 5th KLM out - TB in class.	Tue9th/ Tue16th	Math review + probability problems.	Math review, Ch3	TBC: Math review, 3.1, 3.3[1], 3.4, 3.5.(a)-(f)
2	Mon 8th KLM out		NO CLASS		
	Wed 10th		Basics and Heat, Temperature & Boltzmann Factor	Ch 1,2 & 4	TBC: 1.2[2], 1.4, 2.4, 2.5, 4.2, 4.7, 4.8 +Rewrite derivations in Sections 4.4 & 4.6
	Fri 12th	Sun14th/ Sun21st			
Kinetic Theory of Gases (Part II)					
3	Mon 15th		Maxwell-Boltzmann Distribution	Ch 5	
	Wed 17th				5.1 (mathematica is not needed or allowed), 5.2, 5.5 (demonstrate WHY it makes sense), 5.6
	Fri 19th	Sun 21st/ Sun 28th			
4	Mon 22nd		Pressure Mean Free Path	Ch 6.1-6.2 Ch 8	
	Wed 24th				6.4[3], 6.5 8.4 and Rewrite

[1] Hint: for Q3.3 you will need the Taylor expansion of e^m

[2] Also give the answer in units of Earth masses, 1 $M_\oplus$ = 5.972x10^{24} kg

[3] Also find volume in cubic parsecs (pc). What is the volume (in pc) and pressure (in Pa) if the mass of the cloud is 10^6 $M_\odot$ (assuming it does not become self gravitating)? Compare these pressures to 1 atm (atmospheric pressure on the surface of Earth).

WK	Meeting Date	Due Dates (Draft/Final)	Topic	Reading	**Problems** (Numbering from 2nd Edition)
	Fri 26th	Sun 28th/ Sun 5th			derivation: Section 8.1
Transport & Thermal Diffusion (Part III)					
5	Mon 29th		Transport in Gases Thermal Diffusion	Ch 9.1-9.3 Ch 10.1[4]	
	Wed Oct 1st				9.2[5], 9.4, Rewrite derivation of Eq.9.38 10.1, 10.8
	Fri 3rd	Sun 5th/ Sun 19th			
The 1st Law (Part IV)					
6	Mon 6th		Energy Isothermal & Adiabatic Processes	Ch 11 Ch 12.1-12.3	
	Wed 8th				Questions 11.2, Rewrite Example 11.2 (starting from equations 11.7 and 11.10). Questions 12.2, 12.6
	Fri 10th	Tue 21st/ Sun 26th	NO CLASS (KLM travel)		
FALL BREAK					
The 2nd Law (Part V)					
7	Mon 20th		NO CLASS		

[4] Focus on understanding the theoretical context in S10.1. We will develop our understanding of the various geometries from S10.2-10.4 by *doing* problems (so remember to look back at them when doing the problems).
[5] STP = standard temperature and pressure (0°C and 1 atm)

WK	Meeting Date	Due Dates (Draft/Final)	Topic	Reading	**Problems** (Numbering from 2nd Edition)
	Wed 22nd		Heat Engines	Ch 13.1-13.6	13.1, 13.2, 13.3, 13.4, 13.5
	Fri 24th	Sun 2nd/ Sun 9th			
8	Mon 27th	Fri 31st	**Midterm (topics through Ch12[6])**	Ch1-12	Midterm
	Wed 29th				
	Fri 31st		NO CLASS (GBO trip for ASTR341)		
9	Mon 3rd Nov		Entropy + Information Theory	Ch14, 15	
	Wed 5th				Questions 14.1 (Plus: does the entropy of the Universe increase?), 14.4, 14.8, 15.1, 15.4, 15.6
	Fri 7th	Sun 9th/ Sun 16th			
Thermodynamics (Part VI)					
10	Mon 10th		Thermodynamic Potentials, Magnets, 3rd Law	Ch 16, (skim Ch 17, mainly noting 17.4) Ch 18	
	Wed 12th				16.2[7], 16.3,16.6
	Fri 14th	Sun 16th/ Sun 23rd			18.1, 18.2
11	Mon 17th		Equipartition of Energy Partition Functions	Ch 19 Ch 20	

[6] Aka all topics you should have your “Pretty copy” solutions done for.
[7] Don’t forget to write in words what each quantity on the left is describing like “Change in X with Y at constant Z”. Each of these types of expansion also has a name.

WK	Meeting Date	Due Dates (Draft/Final)	Topic	Reading	**Problems** (Numbering from 2nd Edition)
	Wed 19th				19.5, 20.1 (not last part), 20.2
	Fri 21st	Sun 23rd/ Wed 26th*			
12	Mon 24th		Statistical Mechanics of an Ideal Gas	Ch21	
	Wed 26th	Sun 30th/ Sun 7th			21.4, 21.5
Thanksgiving Break *early deadline intended to help you have a Thanksgiving break					
Statistical Mechanics (Part VII)					
13	Mon 1st Dec		Photons and Phonons	Ch23, 24	
	Wed 3rd				23.3, 23.6, 24.1
	Fri 5th	Sun 7th/ Fri 12th (last day class)			
Advanced topics (TBD)					
14	Mon 8th		How statistical physics matters to me presentations		
	Wed 10th		How statistical physics matters to me presentations		No problem set.
	Fri 12th		How statistical physics matters to me presentations		
Final Ch1-24					