Phys 4409, Winter 2026
Thermodynamics and statistical physics

Course instructor: Dag [Dawg] Gillberg

Email: dag@physics.carelton.ca

Student hour: Fridays 1pm, HP 2404

I'm available in my office (HP 2404) during the student hour to discuss anything related to the class. We can also meet during other times, either in person or over Zoom. Just email me.

TA: Camilla Mupo CamillaMupo@cmail.carleton.ca

Class time: Wed & Friday 11:35-12:55

Class location:

Prerequisites: Phys 3701 (Modern Physics), Math 2004 & 3705 or permission from dept.

Website: carleton.brightspace.com

Welcome to Phys 4409!

This course is meant to develop an integrated understanding of thermal physics both at the **macroscopic** (*thermodynamics*) and at the **microscopic** (*statistical mechanics*) levels. The first part of the course focuses on fundamental principles of thermal physics, including the first and second laws of thermodynamics, entropy and free energy. This is followed by statistical mechanics, including Maxwell-Boltzmann and quantum statistics.

Course delivery: There are two classes per week. You are expected to read the textbook chapters in parallel to attending the lectures. There is also a series of optional, pre-recorded lectures that focuses on the course content.

There are five parts of the course corresponding to the textbook chapters. Each such part has a dedicated module on the course brightspace page that contains:

- Material: pre-recorded lectures and slides. You are expected to review and study this material, including the corresponding sections and example problems in the textbook.
- Brightspace 'pre-lecture' quizzes that must be completed before the Friday lecture, to ensure your reading is in line with the material so you can follow the lectures.

Inclusive teaching statement: *Science is for everyone. I am committed to fostering an environment for learning that is inclusive for everyone. All students in the class, the instructor, and any guests should be treated with respect during all interactions. I would appreciate any feedback related to the class or its delivery throughout the course.*

Land acknowledgement: *We, the people of the Faculty of Science at Carleton University, acknowledge that our campus is located on the traditional, unceded territories of the Algonquin Anishinabeg people. Miigwetch for your hospitality and stewardship of this territory and the teachings that come from it. We are grateful for this land, the air that we breathe, and the water that sustains us all as well as for the animals, plants and other living beings: these enable us to research, teach, mentor, support, study, and learn. We recognize our responsibility to our natural environment and to reconciliation with Indigenous peoples.*

Topics Covered and Learning Outcomes

Week	Topic/Content	Readings/Prep for Class
1 (Jan 7-9) Wed+Fri	Introduction. Thermal equilibrium. Ideal gas law. Equipartition. Heat and work. Compression work. PV curves. Heat capacity and latent heat. The second law. Microstates and macrostates.	Chapter 1.1-1.6, 2.1
2 (Jan 14,16) **A1 due**	Micro/macrostates. Spontaneous processes. The paramagnetic system. The Einstein model of a solid. Large systems.	Chapters 2.1-2.3 Pre-lecture Quiz 1 due
3 (Jan 21, 23)	Interacting systems. Multiplicity of an ideal gas. Entropy. Interacting systems. Temperature.	Chapters 2.3-2.6, 3.1 Pre-lecuter Q2+Q3 due
4 (Jan 28, 30)	Entropy and heat. Measuring entropy. Paramagnetism. Mechanical equilibrium and pressure.	Chapters 3.2-3.4 Pre-lecture Q4 due
5 (Feb 4,6) **A3 due**	Diffusive equilibrium and chemical potential. Summary of thermodynamic equilibria.	Chapters 3.5-3.6 Pre-lecture Q5 due
6 (Feb 11.13)	**Midterm**/review	
7 (Feb 17-21)	Reading week	
8 (Feb 25, 27)	Free energy. Thermodynamic identities. Maxwell's relations. Free energy as force towards equilibrium.	Chapter 5
9 (Mar 4,6) **A5 due**	Extensive and intensive quantities. Gibbs free energy. Phase transformations. Van der Wall model	Chapter 5 Pre-lecture Q6+Q7 due
10 (Mar 11,13)	The Boltzmann factor. Partition functions. Average values. Proof of equipartition. The Maxwell speed distribution.	Chapter 6 Pre-lecture Q8 due
11 (Mar 18) **A6 due**	More on partition functions. Ideal gas revisited. The Gibbs factor.	Chapter 6/7 Pre-lecture Q9 due
12 (Mar 25) **A7 due**	Bosons and fermions. Degenerate fermi gases. Blackbody radiation. The ultraviolet catastrophe. The Planck distribution.	Chapter 7
13 (April 1) **A8 due**	The cosmic microwave background. Debye theory of solids. Bose-Einstein condensation. Review	Chapter 7 Pre-lecture Q10 due
14 (Mar 6)	Review	

Important dates and deadlines: https://carleton.ca/registrar/registration/dates/academic-dates/, including class suspension for fall, winter breaks, and statutory holidays.

Course level learning outcomes

1. Implement problems from both the macroscopic and microscopic perspective
2. Interpret the second law of thermodynamics including: spontaneous process, entropy and “the arrow of time”
3. Model thermodynamic equilibria and phase transitions of systems using free energies
4. Derive thermodynamic properties of systems from thermodynamic identities
5. Implement Boltzman and Gibbs factors and partition functions to describe systems that require quantum statistical treatment such as Fermi gases and blackbodies

Learning material

Required reading

D. Schroeder: *An Introduction to Thermal Physics*

This book was first published by Addison-Wesley, 2000. Since 2021 by Oxford University press. Note: these books have the same content. Using the older one is fine. Price: $46 at Amazon (paperback, new version).

Supplementary material

Concepts in Thermal Physics, Second Edition, Blundell & Blundell, ISBN: 9780199562107

Sears, Salinger: *Thermodynamics, Kinetic Theory, and Statistical Thermodynamics*

(Some material in the lectures are inspired by these texts, students do not need to access to them unless you want to go extra deep into the material)

Course assessment

Component	Grade value
Brightspace Quizzes	5%
In-class Quizzes	5%
Assignments	30%
Midterm	20%
Final exam	40%

Brightspace quizzes

Several quizzes will be released throughout the course. Typically they will have about 5 questions and be due before the Friday lecture (i.e. 11:00 on Fridays). They will be timed at 20 min (or similar). Most questions will be multiple choice, but they might also be "chose one or more options" or simple calculations. Don't forget units!

In-class quizzes

During the lectures there will be frequent quiz questions using Wooclap (wooclap.com). You need to log in using your Carleton credentials and use event code PHYS4409. During class, questions will be activated for a short while to let students figure out the correct answer. Discussion with your neighbour (or small group) is encouraged. After each question, we will discuss the correct answer. This makes the classes more engaging as students take active part in the learning process. Engagement in these questions is worth a total of 5% the final grade split as follows: participation in less than 50% of the questions, gives a mark of zero. If you partake in more than half of the question you receive a mark of 3 (3%) if you have less than 33% correct answers, a mark of 4 if you have (33-66)% correct, and full mark (5%) if >66% correct.

Assignments

An assignment will be due most Fridays, for a total of six to eight assignments. The assignments are posted on the course's Brightspace page with the associated deadline. Late assignments are penalized, unless there is a valid reason (see below). The worst assignment will be ignored in the grade calculation. Students are permitted to discuss concepts and strategies related to solving

the assignments; however, **the work you turn in must be your own**. Feel free to consult me or the TA if you have problems. The assignments are a critical part of the course and working through the problems yourself is essential to learn the material. Your homework solutions should be thorough, self-contained and logical with all steps explained.

Midterm and final examination

The midterm exam will (most likely) be the last lecture before the reading week during the normal lecture slot (80 min) and take place in the normal classroom.
The final exam will take place during the regular examination period at the end of the term. The exact format of the exams will be discussed in advance during the lectures.
The exams will test both conceptual questions and numerical calculations. For the former, you should be able to explain and reason around the concepts of the course (the 'list of concepts' pdf on Brightspace is very useful to prepare for this). The latter will be similar to the assignments problems.

Late and missed work policies

Late work

In case you realize you will not be able to complete your work on time, please let me know before the deadline. If you have a valid reason, or it's the first time you are late, we can arrange an extension. For assignments, the default is a late penalty of 10% of your mark per day you are late. For example, if you are 10 hours late, you will receive a 10% penalty, if you are 40 hours late, -20%, etc. The late penalty tops out at about 50%.

Missed work

As mentioned above, assignments can always be handed in late, however there will be a late penalty. If you miss quizzes or any other evaluation, you can come to discuss your situation at student hours or contact the instructor via email.

Academic accommodations and regulations

Carleton is committed to providing academic accessibility for all individuals. You may need special arrangements to meet your academic obligations during the term. The accommodation request processes, including information about the Academic Consideration Policy for Students in Medical and Other Extenuating Circumstances, are outlined on the Academic Accommodations website (https://students.carleton.ca/course-outline/).

Statement on generative AI usage, such as ChatGPT

As our understanding of the uses of AI and its relationship to student work and academic integrity continue to evolve, students are required to discuss their use of AI in any circumstance not described here with the course instructor to ensure it supports the learning goals for the course.

Use of AI is allowed during the learning process, e.g. to gain deeper understanding of concepts. However, remember to always critically evaluate the answers by AI. They can quite often be wrong, especially for high level topics. So you should always double check the concepts. **The work you submit for evaluation (assignments) must be your own.** Don't use AI to solve any assignment problems. If you use it for part of a problem, you need to state this in the solution you hand in, and if so, always evaluate the output (E.g. 'For this part of the problem, I asked ChatGPT for guidance. The answer I got was XX, which I think is [reasonable because …/not correct because …]').

Statement on Academic Integrity

Students are expected to uphold the values of academic integrity, which include fairness, honesty, trust, and responsibility. Examples of actions that compromise these values include but are not limited to plagiarism, accessing unauthorized sites for assignments or tests, unauthorized collaboration on assignments or exams, and using artificial intelligence tools such as ChatGPT for assessment questions (assignment or quiz questions).

Misconduct in scholarly activity will not be tolerated and will result in consequences as outlined in Carleton University's Academic Integrity Policy. A list of standard sanctions in the Faculty of Science can be found here.

Additional details about this process can be found on the Faculty of Science Academic Integrity website.

Students are expected to familiarize themselves with and abide by Carleton University's Academic Integrity Policy.

Student rights & responsibilities

Students are expected to act responsibly and engage respectfully with other students and members of the Carleton and the broader community. See the 7 Rights and Responsibilities Policy for details regarding the expectations of non-academic behaviour of students. Those who participate with another student in the commission of an infraction of this Policy will also be held liable for their actions.

Student concerns

If a concern arises regarding this course, your first point of contact is me: Email or drop in during student hours and I will do my best to address your concern. If I am unable to address your concern, the next points of contact are (in this order):

Note: You can also bring your concerns to Ombuds services.