

PHYS 602: Statistical Mechanics

Spring 2026

Syllabus

Instructor

Prof. Sebastian Deffner
Physics, Rm. 311
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Time and Place

MoWe 1:00pm – 2:15pm
Janet & Walter Sondheim 409

Office hours

Mo 9:00am – 11:00am
Physics 311

Textbook (required)

Statistical Mechanics in a Nutshell, 2nd edition
L. Peliti
Princeton University Press, ISBN 978-0-6912-4842-4

Literature (highly recommended)

- **Thermodynamics and an Introduction to Thermostatistics (2nd edition)**
H. B. Callen
John Wiley & Sons, ISBN 978-0-4718-6256-7
- **Statistical Physics I**
M. Toda, R. Kubo, & N. Saitô
Springer, ISBN 978-3-5405-3662-8
- **Statistical Physics II**
R. Kubo, M. Toda, N. Hashitsume
Springer, ISBN 978-3-5405-3833-2
- **Introduction to Statistical Physics**
K. Huang
Chapman and Hall/CRC, ISBN 978-1-4200-7902-9

Scope

Review of statistical mechanics of ideal systems, non-ideal gases, phase transitions, Monte Carlo methods, non-equilibrium systems.

Dates

- First day of class: January 26, 2026
- Last day of class: May 12, 2026
- No class on
 - March 16, 2026 (spring break)
 - March 18, 2026 (spring break)
- Written exam: March 25 – April 1, 2026

Course Objectives and Learning Goals

This course will provide a general overview of the main subjects in modern statistical physics. It will discuss key concepts and methods, introduce the relevant terminology, and develop the main ideas of theoretical understanding. You will solve quantitative and complex problems and develop rigorous derivations. As an advanced course special emphasis will be put on deep understanding and mathematically thorough reasoning.

At the end of the course, you should be familiar with:

1. Methods of Statistical Physics

- Probability theory and distributions
- Thermodynamics (phenomenology and exact differential equations)
- Meanfield theory, in particular Ginzburg-Landau theory
- Stochastic processes (Brownian motion and Langevin dynamics)
- Evolution in phase and probability space (Louisville, diffusion and Fokker-Planck equations)
- Monte-Carlo method

2. Systems in thermal equilibrium

- Fundamentals of thermodynamics (laws of thermodynamics, quasistatic processes, equilibrium response functions, equations of state for ideal and non-ideal gases, Maxwell relations)
- Statistical approach (random walks, ergodic hypothesis, statistical ensemble, Maxwell-Boltzmann distribution and thermodynamic ensembles)
- Equilibrium phase transitions (phase equilibrium, Clayperon equation, Maxwell construction, Ginzburg-Landau theory, critical exponents)
- Quantum statistics (Fermi-Dirac and Bose-Einstein distribution)
- Quantum states of matter (photon bunching, Bose-Einstein condensation, superfluidity, superconductors)

3. Systems close to thermal equilibrium

- Linear response and Onsager relations

- Transport phenomena (sound waves, heat conduction, Navier-Stokes equation)
- Nonequilibrium phase transitions (Kibble-Zurek mechanism)

4. Systems far from thermal equilibrium

- Maxwell's demon
- Fluctuation theorem and Jarzynski equality

Course Format

PHYS 602 is a traditional lecture course. Nevertheless, individual reading will play an important role, probably more so than in any other physics course. Only the most important principles and connections will be discussed in class, whereas a big part of the content will be left for reading.

Feel free to ask questions during the lectures, whether you have difficulties with a concept, notice an error, or want to hear more details about an aspect of the material.

Homework

There will be a homework assignment **every** week. The assignments will be posted on Blackboard every Wednesday after class, and submission is due the following Wednesday at 1:00pm.

A homework assignment will consist of two parts:

- Three more complex problems that have to be worked out and written up in detail at home as a usual homework assignment and submitted. These problems will be graded to 4 points each. It will be expected that the submitted problems be written up in a clear, legible, and organized fashion, complete with appropriate verbal comments and figures, very much like examples in the textbook.
- A reading assignment complementary to the material discussed in class. The homework assignments will contain four questions about the reading material, which will amount to another 8 points.

You are allowed, in fact, encouraged, to form study groups and discuss the material and homework questions with each other. However, at the end, the homework solution must be your own work, not a group product. I will give no credit for obvious copies. After all, you are left to your own devices at the tests and in real life. Learn from each other, but be able to work on your own.

Late homework will not be accepted (no exceptions). Homework will be submitted at the beginning of class on the date it is due. Only submissions in OUR OWN HANDWRITING will be accepted. Submission are to be submitted IN PERSON before class on Wednesdays.

Exams

There will be two exams, one written and one oral. The written exam will be "take home". For this exam you will have 1 week to work on the solutions. Expect the exam to be rather challenging and make good use of the time, i.e., do not start working the day before you have to submit.

The oral exam will be conducted during the final exam period at the end of the semester. During this exam you will be asked questions to test your conceptual understanding, and you will work out a few simple derivations on the white board.

Grades

Your grade will be determined as weighted average of your written (65%) and your oral (35%) grades.

For the written grade, there is the following point distribution.

1. Homework assignments (13): 20 points each; 260 points in total.
2. Written exam: 50 points, weighted by a factor of 8; 400 points in total.

This adds up to a possible total of 660 points. A will be given above 90%, A- for at least 85%, B+ for at least 80%, B for at least 75%, B- for at least 70%, C+ for at least 65%, C for at least 60%, C- for at least 55%, and D for at least 40%.

Full credit requires complete and correct solutions. Similarly to the homework assignments each problem in the exams will be graded to 4 points each. This grading scheme might appear rather generous. However, full credit requires complete and mathematical rigorous solutions. Since PHYS602 is an advanced course, mathematical rigor and physically sound reasoning will be expected.

“Incomplete” is given only in exceptional cases. To be considered for an “I”, you must have taken at least one midterm exam, submitted 10 homework solutions, and have C or better standing at the time of incapacitation.

An example: Assume you have achieved 500 points in your written assignments. This translates to 76%, and hence a B letter grade. Now, assume you get a C+ in your oral exam, then your final grade is determined as

$$3.0 * 0.65 + 2.3 * 0.35 = 2.76 . \quad (1)$$

Hence, your final grade is a B-.

Academic Integrity

”By enrolling in this course, each student assumes the responsibilities of an active participant in UMBC’s scholarly community in which everyone’s academic work and behavior are held to the highest standards of honesty. Cheating on a test could result in disciplinary action that may include, but is not limited to, suspension or dismissal.” More on the requirements of academic integrity can be found at <http://www.umbc.edu/gradschool/procedures/integrity.html>

Applied to this course, a proven case of misconduct during a test or a blatant copy or plagiarism of a homework solution “earns” zero on the assignment in question. A second offense will result in failing the course.

All work must be entirely your own. The use of generative AI tools is NOT allowed at any stage of the course, including brainstorming, experiments, coding, research, writing, or revision. If you have any questions, feel free to reach out to me. The use of AI tools will be treated as an academic integrity issue.

Accessibility and Disability Accommodations, Guidance and Resources

Accommodations for students with disabilities are provided for all students with a qualified disability under the Americans with Disabilities Act (ADA & ADAAA) and Section 504 of the Rehabilitation Act who request and are eligible for accommodations. The Office of Student Disability Services (SDS) is the UMBC department designated to coordinate accommodations that creates

equal access for students when barriers to participation exist in University courses, programs, or activities.

If you have a documented disability and need to request academic accommodations in your courses, please refer to the SDS website at sds.umbc.edu for registration information and office procedures.

- SDS email: disAbility@umbc.edu
- SDS phone: 410-455-2459

If you will be using SDS approved accommodations in this class, please contact the instructor to discuss implementation of the accommodations. During remote instruction requirements due to COVID, communication and flexibility will be essential for success.

Sexual Assault, Sexual Harassment, and Gender Based Violence and Discrimination

UMBC Policy in addition to federal and state law (to include Title IX) prohibits discrimination and harassment on the basis of sex, sexual orientation, and gender identity in University programs and activities. Any student who is impacted by sexual harassment, sexual assault, domestic violence, dating violence, stalking, sexual exploitation, gender discrimination, pregnancy discrimination, gender-based harassment, or related retaliation should contact the University's Title IX Coordinator to make a report and/or access support and resources. The Title IX Coordinator can be reached at ecr@umbc.edu or 410-455-1717.

You can access support and resources even if you do not want to take any further action. You will not be forced to file a formal complaint or police report. Please be aware that the University may take action on its own if essential to protect the safety of the community.

If you are interested in making a report, please use the Online Reporting/Referral Form. Please note that, if you report anonymously, the University's ability to respond will be limited.

Notice that Faculty and Teaching Assistants are Mandated Reporters with Mandatory Reporting Obligations.

All faculty members and teaching assistants are considered Mandated Reporters, per UMBC's *Interim Policy on Sex Discrimination, Sex-Based Harassment, and Sexual Misconduct*. Faculty and teaching assistants therefore required to report all known information regarding alleged conduct that may be a violation of the Policy to the Title IX Coordinator, even if a student discloses an experience that occurred before attending UMBC and/or an incident that only involves people not affiliated with UMBC. Reports are required regardless of the amount of detail provided and even in instances where support has already been offered or received.

While faculty members want to encourage you to share information related to your life experiences through discussion and written work, students should understand that faculty are required to report past and present sexual harassment, sexual assault, domestic and dating violence, stalking, and gender discrimination that is shared with them to the Title IX Coordinator so that the University can inform students of their rights, resources, and support. While you are encouraged to do so, you are not obligated to respond to outreach conducted as a result of a report to the Title IX Coordinator.

If you need to speak with someone in confidence, who does not have an obligation to report to the Title IX Coordinator, UMBC has a number of Confidential Resources available to support you:

- Retriever Integrated Health (Main Campus): 410-455-2472; Monday – Friday 8:30 a.m. – 5 p.m.; For After-Hours Support, Call 988.

- Center for Counseling and Well-Being (Shady Grove Campus): 301-738-6273; Monday-Thursday 10:00a.m. – 7:00 p.m. and Friday 10:00 a.m. – 2:00 p.m. (virtual) Online Appointment Request Form
- Pastoral Counseling via The Gathering Space for Spiritual Well-Being: 410-455-6795; i3b@umbc.edu; Monday – Friday 8:00 a.m. – 10:00 p.m.
- Women, Gender, and Equity Center (open to students of all genders): 410-455-2714; womenscenter@umbc.edu; Monday – Thursday 9:30 a.m. – 5:00 p.m. and Friday 10:00 a.m. – 4 p.m.

Please note that Maryland law and UMBC policy require that faculty report all disclosures or suspicions of child abuse or neglect to the Department of Social Services and/or the police even if the person who experienced the abuse or neglect is now over 18.

Pregnant and Parenting Students

UMBC's *Interim Policy on Sex Discrimination, Sex-Based Harassment, and Sexual Misconduct* expressly prohibits all forms of discrimination and harassment on the basis of sex, including pregnancy. Resources for pregnant, parenting and breastfeeding students are available through the University's Office of Equity and Civil Rights. Pregnant and parenting students are encouraged to contact the Title IX Coordinator to discuss plans and ensure ongoing access to their academic program with respect to a leave of absence – returning following leave, or any other accommodation that may be needed related to pregnancy, childbirth, adoption, breastfeeding, and/or the early months of parenting.

In addition, students who are pregnant and have an impairment related to their pregnancy that qualifies as disability under the ADA may be entitled to accommodations through the Office of Student Disability Services.