

Graduate Statistical Mechanics

PHY 603

2024 Fall Semester

Tuesday and Thursday, 11:00 am to 12:15 pm, Room: TEC 112/Online via Team

***Contacting Your Instructor(s)**

Name	Dr. Partha Biswas
Office address	112 TEC
Office hours	By appointment
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Phone	

Teaching Assistants [if applicable]: None

Name
Office address
Office hours
Email
Phone

Course Objectives

The main objective of the course is to study a statistical description of many-particle systems from classical and quantum-mechanical points of view. Unlike classical physics, where the focus is on particle and rigid-body dynamics, in statistical mechanics one develops a probabilistic viewpoint of a collection of very many particles. The emphasis is on the collective motion and properties of a complex system -- consisting of an ensemble of interacting particles -- for which exact solutions are not possible. Instead of providing a deterministic solution of a problem, statistical mechanics aims to provide the information on the average behavior of a system in equilibrium. The field is one of the most important branches of theoretical physics, supported by elegant mathematical methods and experimental results. As a part of the course, you will learn some key statistical ensembles and their applications to physics.

Course Description

The following are the anticipated topics that would be discussed in the class. Depending on the progress of the class and the rigor of the materials, some of the topics may or may not be covered.

Mathematical preliminaries

Phase-space density, ergodic hypothesis, Liouville's theorem, Microcanonical ensemble, Canonical Ensemble, Gibbs Paradox, Applications of Boltzmann statistics, Non-interacting system of particles, Fluctuations, Virial and Equipartition theorems, Concept of Entropy from the statistical point of view, Phase transitions, Ising models in 1- and 2-dimension, Introduction to Landau theory of phase transition

Basics of quantum statistical mechanics, Ideal Quantum Gases, Bose and Fermi gases, The Grand potential, Classical limits and the ideal Fermi and Bose gases; The Photon gas – the blackbody distribution; Phonons in Solids, Specific heat of solids; Bose-Einstein condensation, Statistical mechanics of stars (optional)

Course Learning Outcomes

By the end of the course, you will learn some basic concepts of statistical mechanics with applications to classical and quantum gases, spin systems, and some mathematical methods.

Course Materials

Since this is a graduate level course, we will use a variety of sources including review articles and research papers. Course materials will be provided in the form of class lectures and that will be the basis of your learning. The level of course materials will be based on the following book:

Thermodynamics and Statistical Mechanics by Walter Greiner, Springer, ISBN: 978-0-387-94299-5

References for a few additional texts or monograph (optional) for consultation will be provided in the first week of the class.

Course Requirements

Students are expected to meet the following requirements in order to successfully complete the course: 1) Presentation of an assigned project or special topic by doing literature survey and/or a problem; 2) Attending all regular tests and the final examination; 3) Attending regular classes. You are required to present in the class in person or online synchronously, unless you have permission from the instructor. Please notify your instructor by email if you cannot attend a lecture; 4) Completion of home assignments in a timely manner; 5) A good knowledge of undergraduate (UG) Thermal Physics and Mathematical Physics is needed for this course. If you do not have a prior experience with Thermal Physics, please contact your instructor so that he/she/they can advise you accordingly.

Course Communication

The course will be delivered in-person and online. The presentation is hybrid and synchronous in nature, meaning online students are required to join the course via MS Team links provided by the instructor during the time scheduled in SOAR. The in-person students will be joined in the class as usual. Course materials will be uploaded as a pdf file regularly to a faculty web site maintained by the instructor. The link for the materials will be provided via email through SOAR. Office hours will be provided as and when needed and it will be by appointment. Most communications will take place during class.

Course Evaluation

Students will be evaluated during the semester by taking a final exam (40% weight), a mid-term exam (20% weight), a special topic presentation toward the end of the course (20% weight), and homework (20% weight). Homework includes unannounced/impromptu quizzes during class hours.

Course Workload Statement

Students are expected to invest considerable time outside of class in learning the material for this course. Graduate Statistical Mechanics is a difficult course and students need a strong background in Classical Mechanics and Mathematical Physics. A significant effort on the part of the students is needed to grasp some of the difficult but most beautiful concepts in Statistical Mechanics. For each hour of the class, students may expect to spend 5-8 hours depending upon their prior background and preparation for the course.

We realize that most students work and have family or other obligations. Time management is thus critical for student success. All students should assess their personal circumstances and talk with their advisors about the appropriate number of credit hours to take each term, keeping in mind that, for UG/graduate students, 30/20 credit hours each year are needed to graduate in four/two years. Resources for academic, technical, self-help, social, etc, can be found at [Student Help | The University of Southern Mississippi \(usm.edu\)](http://www.usm.edu/student-help)

Grading Policies and Calculation

Your final letter grade will be determined by the following scale. See course evaluation section.

A \geq 90
A- \geq 85 – 89
B+ \geq 80 – 84
B \geq 70 – 79
B- \geq 65 – 69
C+ \geq 60 – 64
C \geq 55 – 59
C- \geq 50 – 54
D+ \geq 45 – 49
D \geq 40 – 44
D- \geq 35 – 39
F < 34

Students may drop a course with no penalty in the first week of the semester. If students wish to leave a course with a grade of “W” (for “withdrawal”), they may request to do so before the 50th day (specific dates can be found here: <https://www.usm.edu/registrar/calendars>). Important note: Students who receive a grade of W **do not receive any money back** and that grade is permanently included on their transcripts.

Students should be aware that “Incompletes” can only be assigned in cases of “extraordinary circumstances” beyond the student’s control.

Academic Integrity Statement

Academic misconduct involves deception to improve a grade, earn course credit, complete a degree, or create an unfair academic advantage for oneself or disadvantage to another in the academic community. All students at the University of Southern Mississippi should familiarize themselves with the [Student Academic Integrity Policy](#) to become familiar with what actions constitute academic misconduct, a violation of that policy. Southern Miss values “an approach to academics, research, and personal conduct based on integrity and civility” and the Student Academic Integrity Policy supports that University value. Forms of academic misconduct may include, but are not limited to:

- **Cheating** - Cheating is a broad category of academic misconduct characterized by an attempt to gain academic advantage through inappropriate means or impede the academic achievement of others.
- **Plagiarism** - The use of another person's or source's words, creative works, or ideas without appropriate quotation or attribution; claiming or submitting for academic credit the work of another.
- **Lying** - The misrepresentation of one's academic work, lying to an instructor to increase a grade, or lying to an instructor regarding an academic integrity violation.
- **Acquiring or Distributing Information Inappropriately** - The act of distributing or obtaining course assignments or examination questions or answers from sources not approved by the instructor or proctor (includes, but is not limited to, unauthorized use of the Internet, test banks associated with course text and previous student work).
- **Fabrication or Falsification of Data** - Any statement of untruth in any matters related to the academic experience, including but not limited to forgery; false claims of authorship; falsification of information, data, or results derived from or related to research or to laboratory experiments.
- **Stealing or Defacing** - The act of intentionally taking, transferring, defacing, or destroying, without right or permission, any property related to the academic mission of the University, including an attempt to impede others.
- **Multiple Submissions** - The submission, more than once, without authorization by any instructors involved, of substantial portions of the same work, including oral reports or work submitted for retaken courses.
- **Conspiracy** - The act of agreeing or planning with any person to commit any violation of the Student Academic Integrity Policy.

If you commit an act of academic misconduct, sanctions ranging from resubmission of work to course failure may occur to the possibility of receiving a grade of “XF” for the course, which will be on the student’s transcript with the notation “Failure due to academic misconduct.” Should you be accused of academic misconduct, please visit the [Academic Integrity Website](#) or email integrity@usm.edu for any questions you may have about your rights and about the academic integrity process. Southern Miss provides many campus resources that are detailed in this syllabus and will be discussed by your professors; please utilize those to help you learn. At Southern Miss, we care about your personal work and learning journey.

Artificial Intelligence Syllabus Statements

Option 3: Prohibitive Use

The use of generative Artificial Intelligence (AI) in any form is not permitted in this class. Any use of AI tools for work in this class will be considered a violation of the University of Southern Mississippi's Academic Integrity policy. The instructor of your course reserves the right to send any submitted work to AI detection software. The use of unauthorized AI tools (such as ChatGPT or any other bots or automated digital solvers) will result in consequences deemed appropriate by the instructor and will be subject to the Academic Integrity Policy and the University of Southern Mississippi. Should it be needed, the instructor may ask you to present live demonstration any homework problems that you submit in the class for evaluation.

Student Accessibility Services (SAS)

SAS is Southern Miss's designated office to assist the University in its commitment to protect the civil rights of students with disabilities. SAS protects students from discrimination and offers reasonable accommodations to give them equitable access to university courses and resources. Disabilities covered under the ADA may include but are not limited to ADHD, learning disabilities, psychiatric disabilities, physical disabilities, chronic health disorders, temporary injuries, and pregnancies. If a student feels that they need classroom or housing accommodations based on a disability they should contact SAS by phone at 601-266-5024, by email at sas@usm.edu, in person by visiting the SAS office located in McLemore Hall, Room 112, or online at www.usm.edu/sas.

Land and Labor Acknowledgement

The University of Southern Mississippi acknowledges the original inhabitants of the land upon which the Hattiesburg and Gulf Park campuses are built. We honor the unnamed ancestors who were the first to walk the Pine Hills and Gulf Coastal Plain, those whose origin and migration stories, medicine and plant knowledge are of this place. We offer our respect to the living descendants of those people, and to those who still occupy this territory as a sovereign nation, The Mississippi Band of Choctaw Indians. (provided by the Center for American Studies and Research faculty, 2022)

Also, I want to respectfully acknowledge the enslaved peoples, primarily of African descent, who provided exploited labor to build and maintain many higher education institutions. I am indebted to their labor and to the labor of many who continue to work in the shadows for our collective benefit. I implore us as higher education scholars and practitioners to continue to remember and honor those whose land we occupy and whose labor we benefit from throughout the semester. (shared with permission from Dr. Jason Wallace, Assistant Professor, USM.)

Career Services

Career Services staff strive to assist students in finding meaningful career paths, developing job-seeking skills and connecting with employment opportunities. Students will find assistance through personal meetings, on-line resources and attending events such as the Career and Internship Expos. Students are encouraged to attend the Career and Internship Expo each semester to explore potential career paths, identify internships, discover job opportunities, and build professional connections with employer contacts. 80 to 100 employers and graduate school representatives attend each semester. Dates and

additional information on our website at www.usm.edu/cs or check out the events section in your Handshake account.

Copyright Statement

My lectures and course materials, including PowerPoint/pdf presentations, tests, outlines, syllabus, handouts, video/audiorecordings of my lectures, and similar materials, are protected by copyright. That means that I am the exclusive owner of those materials I create, and no one but me can edit them, give them to others, post them anywhere online, or copy them to distribute in any way. You may take notes and make copies of course materials for your own personal use, and you and other students in the class may share notes and materials when studying. Any other sharing of lecture notes or any course materials cannot be done unless you have my explicit permission in writing, whether you are paid for the materials or not. Similarly, I will not share anything you submit in the class unless I have your written permission. If you upload your class notes or any materials (problems, solutions, etc.) from this class to any website or give them to anyone, this act is a violation of copyright and is considered academic misconduct. If you do that, you will be subject to the penalties outlined in the University's Academic Integrity Policy. If you have any questions at all about copyright or academic integrity, please let me know.

Student Support Resources

Need help?

Our goal is to ensure students have the resources that they need to be successful. Students needing support for academics, financial assistance, technical assistance, or mental, emotional, recovery, or other needs can use usm.edu/help to guide them to the resources available on campus as well as self-help options.

Student Rights and Consultation

[The Dean of Students Office](#) can help you if you need information about your rights and responsibilities as a student, guidance in navigating university policies and procedures, need consultation on, or to report, a concern, referrals to campus resources, assistance with an academic notification to instructors about an extended absence, or to initiate a late withdrawal from a course or the university.

[Academic Notification](#) The Dean of Students Office will support students experiencing a crisis and/or medical emergency that causes the student to miss **more than three consecutive days** of classes and can provide documentation to a faculty member regarding the validity the absence. However, the documentation provided by this office does not "excuse", nor does it guarantee, that the student will be permitted to make up tests or other missed assignments; it simply documents that the student's circumstance(s) indicates that the student is/was unable to participate in class for the designated period of time. At their discretion, the instructor will make the final decision about the opportunity to complete missed course work. Students are encouraged to reach out to their instructors as soon as possible before or after any absence.

The Academic Success Center at Gulf Park

The Academic Success Center is located on the second floor of the Gulf Coast Library on the Gulf Park campus in Long Beach. Through peer tutors and professional support staff, the Academic Success Center offers a broad range of services including:

- Academic Coaching
- Learning materials and electronic resources
- Individual and small group tutoring
- Whole class support
- Proctoring: IVN classes and in-person at the Testing Center in the Gulf Coast Library
- Workshops and seminars
- Online and in person tutoring sessions in a variety of subjects

For more information, visit us at www.usm.edu/asc. To make an appointment, please visit <https://gulfpark.mywconline.com/>. If you have questions about our services, call us at 228.214.3346 or 228.214.3467 or email us at academic.success@usm.edu.

Speaking and Writing Centers

The **Writing Center** and the **Speaking Center** are friendly spaces that provide individualized feedback and support to help Southern Miss students succeed with writing and speaking assignments for any class. The Centers offer one-to-one consultations for any stage of the process, including brainstorming, creating an outline, revising, learning editing strategies, and developing presentation skills. In-person and online appointments are available. To make an appointment, visit usm.mywconline.com and create an account. Instructions for making an appointment can be found at usm.edu/writing-center. Contact the Writing Center (Cook Library 112) by email at writingcenter@usm.edu or by phone at (601) 266-4821. The Speaking Center (Cook Library 117) can be reached at speakingcenter@usm.edu or (601) 266-4965.

Career Services

Career Services staff strive to assist students in finding meaningful career paths, developing job-seeking skills and connecting with employment opportunities. Students will find assistance through personal meetings, on-line resources and attending events such as the Career and Internship Expos. Students are encouraged to attend the Career and Internship Expo each semester to explore potential career paths, identify internships, discover job opportunities, and build professional connections with employer contacts. 80 to 100 employers and graduate school representatives attend each semester. Dates and additional information on our website at www.usm.edu/cs or check out the events section in your Handshake account.

University Libraries

Southern Miss Libraries provide students with individualized assistance using library resources for coursework and scholarly research. Questions may be asked in person or by live chat, telephone, or email. Students may request a research consultation with a librarian to get help at any stage of the research process. Research consultations, available in-person and online, provide personalized assistance that is tailored to a class assignment or project. Librarians can help students search for, find, and obtain sources for their research projects.

The University Libraries' website (www.lib.usm.edu) provides information about conducting academic research, as well as links to the Libraries' search tool (Seymour Info), databases, and other resources. Library research guides are available through Canvas, as well as the library website. University Libraries also have a robust interlibrary loan (ILL) service which provides access to resources not available in our current collections or subscriptions. The Libraries at Southern Miss provide access to both print and electronic resources, including books, journal articles, newspapers, digital media, and more. University Libraries also include Special Collections which offer a variety of historical resources, such as rare books and historical artifacts, in addition to University Archives which offer documents and memorabilia from our University's rich history. Visit your campus library or the University Libraries' website to get started!

Financial Management Resources

The University of Southern Mississippi recognizes that students, faculty, and staff members may experience financial challenges beyond their control that impact their ability to finance their education or establish a work-life balance that fosters academic success. If you find yourself in need of financial education, resources, or professional services, please visit the Office of Undergraduate Scholarships' Financial Management Resource Center site at <https://www.usm.edu/undergraduate-scholarships/financialcenter.php> or use your USM credentials to receive customized help through iGrad at <https://southernmiss.igrad.com/>.

Food Insecurity and Student Homelessness Statement (Hattiesburg Campus)

The University of Southern Mississippi recognizes that students and staff members may experience challenges beyond their control that impact their ability to take care of their essential needs, such as having food or a safe place to sleep. If you find yourself in need of food or shelter, please consider contacting the Eagle's Nest Food Pantry on the Hattiesburg campus at 601-266-4025 or eaglesnest@usm.edu. All students, faculty, and staff are welcome to come to the Eagle's Nest Food Pantry and utilize the available resources free of charge.

Food Insecurity and Student Homelessness Statement (Gulf Park Campus)

The University of Southern Mississippi recognizes that students and staff members may experience challenges beyond their control that impact their ability to care for their essential needs, such as having food or a safe place to sleep. If you find yourself in need of food, please consider contacting the Gulf Park Food Pantry at 228.214.3341 or gulfparkpantry@usm.edu. All students, faculty, and staff are welcome to come to the Food Pantry and utilize the available resources free of charge. If you find yourself in need of shelter, please consider contacting Jessica Langston, Director of Student Engagement and Strategic Initiatives at 228.214.3222 or Jessica.Langston@usm.edu.

Mental Well-Being Statement

USM recognizes that students sometimes experience challenges that make learning difficult. If you find that life stressors such as anxiety, depression, relationship problems, difficulty concentrating, alcohol/drug problems, or other stressful experiences are interfering with your academic or personal success, consider contacting Student Counseling Services (SCS) on campus at 601-266-4829. More information is also available at <https://www.usm.edu/student-counseling-services>, or usm.edu/help. Student Counseling Services offers currently enrolled students free, confidential counseling services and can provide referrals to campus and community resources. Currently enrolled students living outside Mississippi can receive a one-time consultation to assure they are informed about available resources in their community. Students on the Gulf Park campus also can contact our Mental Wellness Counselor at Alvin.Baker@usm.edu.

In the event of emergency, please call 911 or if there is a mental health crisis after business hours, call or text the National Suicide Hotline at 988 (988lifeline.org).

