

## Graduate Statistical Mechanics

**PHY 603**

**2023 Fall Semester**

**Tuesday and Thursday, 11:00 am to 12:15 pm, Room: WSB 227**

### **\*Contacting Your Instructor(s)**

Name	Dr. Partha Biswas
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Office hours	By appointment
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Phone	601.266.5156

Teaching Assistants [if applicable]:

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 dynamical 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 the key statistical ensembles and their applications to physics.

### **Course Description**

Random variables, moments, and characteristic function; Addition of random variables; Gaussian distribution; The central limit theorem; Random processes, Stationarity and Ergodicity

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. 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

### **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 unless you have permission from the appropriate university authority. 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 Mathematics 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 students are required to attend the class in person. This does not apply to online programs.

### **Course Workload Statement**

Students are expected to invest considerable time outside of class in learning the material for this course. The expectation of the University of Southern Mississippi is that each week students should spend approximately 4 hours outside of class for every hour in class working on reading, assignments, studying, and other work for the course. For online classes, the average amount spent on a three-credit-course is roughly ten hours per week, including all assignments and interactions.

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)

### Grading Policies and Calculation

Your final letter grade will be determined by the following scale:

A  $\geq$  90  
A-  $\geq$  85 – 89  
B+  $\geq$  80 – 84  
B  $\geq$  75 – 79  
B-  $\geq$  70 – 74  
C+  $\geq$  65 – 69  
C  $\geq$  60 – 64  
C-  $\geq$  55 – 59  
D+  $\geq$  50 – 54  
D  $\geq$  45 – 49  
D-  $\geq$  40 – 44  
F < 40

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 50<sup>th</sup> 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](mailto: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) is not permitted in this class. Any use of AI tools for work in this class may 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 will result in consequences deemed appropriate by the instructor and will be subject to the Academic Integrity Policy and the University of Southern Mississippi.

### **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](mailto:sas@usm.edu) , in person by visiting the SAS office located in Bond Hall Room 114, or online at [www.usm.edu/sas](http://www.usm.edu/sas) .

### **COVID-19 Protocol, Fall 2023 (Optional)**

Southern Miss is operating under normal procedures on all campuses, teaching, and research sites. Face masks are no longer required in public spaces unless you have COVID-19 symptoms, a positive COVID-19 test, or close contact exposure to someone with COVID-19. You may choose to wear a mask at any time, based on your personal health circumstances, and healthcare settings may require face masks during times of high community transmission. The CDC recommendation for mask use is fluid, depending on the level of community transmission and a person's risk for serious illness. Please refer to our [COVID health protocols site](#) for the most up-to-date information.

All eligible students, faculty, and staff are strongly urged to get a [COVID-19 vaccination](#) and all applicable [boosters](#), which are now widely available:

- [Schedule an Appointment – Hattiesburg Campus](#)
- [Schedule an Appointment – Gulf Park Campus](#)
- [Schedule an Appointment in Your Current Area](#)

For everyone in the Southern Miss community, staying physically and mentally healthy is important. [Moffitt Health Center](#) provides health care services through online resources and appointments with care providers. Students who become ill with fever or other symptoms should contact Moffitt for information or to see a care provider. If a student is required to isolate during the semester due to a diagnosed illness, we ask that faculty give that student consideration for make-up work.

In addition to physical health care, students may also access a variety of [resources](#) to support mental well-being, from online resources to in-person counseling for students through [Student Counseling Services](#). If you have concerns about your well-being, please contact one of these resources for support.

### **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](http://www.usm.edu/cs) or check out the events section in your Handshake account.

### **Copyright Statement**

My lectures and course materials, including PowerPoint presentations, tests, outlines, syllabus, handouts, recordings 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 permission in writing, whether you are paid for the materials or not. Similarly, I will not share anything you submit to me unless I have your written permission. If you upload your notes or any materials 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](http://usm.edu/help) to guide them to the resources available on campus as well as self-help options.

### **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](http://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](mailto: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](http://usm.mywconline.com) and create an account.

Instructions for making an appointment can be found at [usm.edu/writing-center](http://usm.edu/writing-center). Contact the Writing Center (Cook Library 112) by email at [writingcenter@usm.edu](mailto:writingcenter@usm.edu) or by phone at (601) 266-4821. The Speaking Center (Cook Library 117) can be reached at [speakingcenter@usm.edu](mailto:speakingcenter@usm.edu) or (601) 266-4965.

### **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](http://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!

### **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](mailto: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](mailto: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](mailto: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](http://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](mailto: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](https://988lifeline.org)).*

#### **Nondiscrimination Statement:**

The University of Southern Mississippi offers to all persons equal access to educational, programmatic and employment opportunities without regard to age, sex, sexual orientation, disability, pregnancy, gender identity, genetic information, religion, race, color, national origin, and/or veteran status pursuant to applicable state and federal law.

#### **Confidentiality and Mandatory Reporting**

*[The Title IX office urges all instructors to consider adding this statement to your syllabi, or to read the statement during the first class meeting. Questions about this request can be directed to Cristin Reynolds [Cristin.Reynolds@usm.edu](mailto:Cristin.Reynolds@usm.edu) or by calling 601.266.6804.]*

As an instructor, one of my responsibilities is to help create and maintain a safe learning environment on our campus. I also have a mandatory reporting responsibility related to my role as a faculty member. I am required to share information regarding sexual misconduct or information about a crime that may have occurred on USM's campus with certain University officials responsible for the investigation and remediation of sexual misconduct. The information will remain private and will only be shared with those officials necessary to resolve the matter. The sharing of information to the Title IX Office does not initiate a Title IX investigation or the criminal investigation process. Reporting to the Title IX Office initiates office outreach to those impacted by the alleged behavior to discuss available resolution options and supportive measures. You do not have to file a formal complaint with the Title IX Office in order to access on and off campus supportive measures. If you would like to speak in confidence, resources available to students include Confidential Advisors with the Shafer Center for Crisis Intervention, the Counseling Center, Student Health Services, and Clergy. More information on these resources and University Policies is available at [www.usm.edu/title-ix](http://www.usm.edu/title-ix).

#### **Class Schedule**

*[This section outlines the course schedule for the students, ideally including the date, class preparation required, topic, and any in-class activities or obligations that day. Tests and other requirements should also be included to re-iterate when they are due. Example is below. This can be placed in your syllabus where preferred.]*

<i>Date</i>	<i>Topic</i>	<i>What should be done before class</i>	<i>Assignments due or other important reminders</i>
<b>TH 1/19</b>	Introduction to the class		
<b>TU 1/24</b>	Reality as a social construction	Read Best, <u>Social Problems</u> , pgs. 3-14; watch YouTube video (see Canvas); 2 blog entries (see Canvas)	<b>January 20 is last day to drop &amp; get a refund.</b>
<b>TH 1/26</b>	Claims and claims-making	Read Best, pgs. 14-28; Read Silver, <u>Social Problems Readings</u> , reading #5	



