PHYS 758 | **Statistical Physics** | **Spring 2025**

Course # 34545 (3 credits)

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http://www.ndsu.edu/pubweb/~denton/

Classes: TuTh, 9:30-10:45 AM, SE 221 **Help:** on demand (in-person/Zoom)

Bulletin Description: Review of thermodynamics and statistical mechanics; Monte Carlo and molecular dynamics simulation; applications to phase transitions.

Prerequisite: PHYS 462/662 Thermal and Statistical Physics (or equivalent)

Objectives: Develop conceptual and technical mastery of theoretical and computational methods of statistical physics and applications to a variety of many-particle systems.

Preparation: Basic knowledge of mechanics, thermodynamics, statistics, and mathematical methods. Some familiarity with numerical methods and programming.

Format: Please review assigned resources in advance and attend class prepared to discuss and work through guided exercises. You are not expected to fully understand the material before class, but be familiar with terminology and definitions. In this way, class time can be used more effectively to deepen conceptual understanding, strengthen problem-solving skills, and discuss practical relevance and applications.

Textbook: R. K. Pathria & P. D. Beale, *Statistical Mechanics*, 3rd ed. (Elsevier, 2011)

Inclusive Access: To avoid charges, be sure to opt out before the Bookstore's deadline.

Evaluation:

Homework	100 pts	(written solutions and in-class presentations)
Exams	200 pts	(lowest midterm score dropped; makeup final)
Quizzes	50 pts	

Attendance is expected: NDSU Policy 333, www.ndsu.edu/fileadmin/policy/333.pdf
Active engagement in class discussions is strongly correlated with success in this course!
More than three unexcused absences may result in failure, so please be sure to attend.

Homework: Assignments will be posted on Blackboard (https://bb.ndsu.nodak.edu).
Class time will be allotted for group work on assigned problems. A representative from each group will be asked to present solutions and guide discussions in class (see Rubric). Completed work must be handwritten and may be submitted on paper or via Blackboard.
While discussion of homework with classmates is encouraged, submitted work must be your own. Close similarity to other students' or internet solutions will yield no points.
Check your work with online or AI tools, but beware of risking your own understanding!

Quizzes: Short quizzes to guide reading assignments will be posted on Blackboard.

Grading: A: $\geq$ 90%, B: 80 to $<$ 90%, C: 70 to $<$ 80%, D: 60 to $<$ 70%, F: $<$ 60%

Grades will not be curved and any shift in grade boundaries will be only in your favor.

Health and Safety Expectations

Do not come to class if you are sick or, if infected by COVID-19, during your five-day isolation period. Do not come to class if you have been exposed to individuals who tested positive for COVID-19 and/or you have been notified to self-quarantine due to exposure. Requests for remote participation due to health concerns will be accommodated.

Contingency Plan for Remote Instruction and Learning

Should any circumstances necessitate strictly online instruction, all course resources will remain accessible through Blackboard and communications and interactive discussions will continue via email and video conference (Zoom).

Preliminary Schedule

(PB=Pathria & Beale; C=Chandler)

Dates	Topic(s)	Reading
Weeks 1-3	Statistical Thermodynamics, Ensembles	PB 1-4; C 1-3
Week 4	Quantum Statistics: Bosons and Fermions	PB 5; C 4
Week 5	Theory of Simple Gases	PB 6; C 4
Feb. 20	**Midterm Exam 1**	PB 1-6; C 1-4
Weeks 6-7	Ideal Bose and Fermi Systems	PB 7-8; C 4
Weeks 8-9	Statistical Mechanics of Interacting Systems	PB 9-11; C 5, 7
March 14-18	Spring Break (no classes)	
Weeks 10-11	Phase Transitions, Critical Phenomena, Scaling	PB 12; C 5
March 27	**Midterm Exam 2**	PB 6-11; C 4-7
Week 12	Phase Transitions: Exact Solutions of Various Models	PB 13; C 5
Week 13	Phase Transitions: Renormalization Group Theory	PB 14; C 5
Week 14	Statistical Mechanics of Nonequilibrium Systems	PB 15; C 8
May 1	**Midterm Exam 3**	PB 10-14; C 5-8
Weeks 15-16	Computer Simulation Methods	PB 16; C 6
May 14, 1:00 PM	**Final Exam**	PB 1-16; C 1-8

The academic community is operated on the basis of honesty, integrity, and fair play. NDSU Policy 335: Code of Academic Responsibility and Conduct applies to cases in which cheating, plagiarism, or other academic misconduct have occurred in an instructional context. Students found guilty of academic misconduct are subject to penalties, up to and possibly including suspension and/or expulsion. Student academic misconduct records are maintained by the Office of Registration and Records. Informational resources about academic honesty for students and instructional staff members can be found at `www.ndsu.edu/academichonesty`.

All access to NDSU computers must respect NDSU Senate Policy, section 158: Acceptable use of Electronic Communication Devices
`https://www.ndsu.edu/fileadmin/policy/158.pdf`

Any students with disabilities or other special needs, who need special accommodations in this course are invited to share concerns or requests with the instructor and to contact the Center for Accessibility and Disability Resources as soon as possible.
`https://www.ndsu.edu/accessibility_disability`

Computational Examples and Exercises

To deepen conceptual understanding and build computational skills, we will make use of *Simulations in Physics* in the Open Source Physics Library, free Java code that can be downloaded, compiled, and run on any computer (instructions on Blackboard).

Problem Set Guidelines and Expectations

Together with your group, in and out of class, discuss and solve all assigned problems.

Each group member contributes to discussions and writes solutions in their own words.

A complete written solution includes (1) statements of physical concepts and principles, (2) definitions of all symbols, (3) explanations in words of all steps, and (4) conclusion (interpreting significance). A series of equations lacking context is <u>not</u> acceptable.

Each group collaborates and submits <u>one set</u> of <u>handwritten</u> solutions.

Each group member prepares to present solutions in class (all are accountable).

Rubric for Evaluating Presentations of Solutions

Element	**Expectations**	**Score**
clarity	identify concepts, define symbols, write legibly	3
completeness	show all steps and explain reasoning	3
accuracy	reason logically to obtain correct results	3
interpretation	explain meaning and significance of results	3
accountability	answer questions and defend solution	3
Total		15

Supplemental References

D. Schroeder, *An Introduction to Thermal Physics* (Addison-Wesley, 2000)

D. Chandler, *Introduction to Modern Statistical Mechanics* (Oxford, 1987).

F. Reif, *Fundamentals of Statistical and Thermal Physics* (McGraw-Hill, New York, 1965).

D. McQuarrie, *Statistical Mechanics* (Harper & Row, New York, 1976).

T. L. Hill, *Introduction to Statistical Thermodynamics* (Addison-Wesley, Reading, Mass., 1960).

K. Stowe, *An Introduction to Thermodynamics and Statistical Mechanics*, 2^{nd} edition (Cambridge, New York, 2007).

L. D. Landau and E. M. Lifshitz, *Statistical Physics*, 3^{rd} edition, Part 1 (Pergamon, Oxford, 1980).

M. Plischke and B. Bergersen, *Equilibrium Statistical Physics* (World Scientific, Singapore, 1994).

L. E. Reichl, *A Modern Course in Statistical Physics* (University of Texas, Austin, 1980).

R. Kubo, *Statistical Mechanics* (North-Holland, Amsterdam, 1965).

S. K. Ma, *Statistical Mechanics* (World Scientific, Philadelphia, 1985).

S. K. Ma, *Modern Theory of Critical Phenomena* (Benjamin, Reading, Mass., 1976).

H. E. Stanley, *Introduction to Phase Transitions and Critical Phenomena* (Oxford, New York, 1971).

J.-P. Hansen, I. R. McDonald, *Theory of Simple Liquids*, 3^{rd} edition (Academic, 2006).

J. M. Yeomans, *Statistical Mechanics of Phase Transitions* (Oxford, 1992).

R. Phillips, J. Kondev, and J. Theriot, *Physical Biology of the Cell* (Garland Science, New York, 2009).

K. A. Dill and S. Bromberg, *Molecular Driving Forces: Statistical Thermodynamics in Biology, Chemistry, Physics, and Nanoscience*, 2^{nd} edition (Garland Science, New York, 2009).

R. J. Baxter, *Exactly Solved Models in Statistical Physics* (Academic, San Diego, 1982).

C. Domb, *The Critical Point: A Historical Introduction to the Modern Theory of Critical Phenomena* (Taylor & Francis, London, 1996).

M. Kardar, *Statistical Physics of Particles*, 1^{st} edition (Cambridge, 2007).