

**PHYSICS 5705 — STATISTICAL MECHANICS**  
**Syllabus — Spring 2024, CRN 19236**

- Instructor: Uwe C. Täuber  
Phone (home): (540) 961-5222  
Email: tauber@vt.edu
- Recommended texts: *Statistical Mechanics*, 2nd ed., by Franz Schwabl (Springer, 2006);  
*Statistical Mechanics*, 4th ed., by R.K. Pathria and Paul D. Beale (Academic Press, 2021).
- Also recommended: *Fundamentals of Statistical and Thermal Physics*, by F. Reif (McGraw-Hill, 1965);  
*Statistical Physics I – Equilibrium Statistical Mechanics*, 2nd ed., by M. Toda, R. Kubo, and N. Saitô (Springer, 1992),  
*Statistical Physics II – Nonequilibrium Statistical Mechanics*, 2nd ed., by R. Kubo, M. Toda, and N. Hashitsume (Springer, 1991);  
*Statistical Thermophysics*, by H.S. Robertson (Prentice Hall, 1998);  
*Statistical Physics of Particles*, by M. Kardar (Cambridge, 2007);  
*Equilibrium and Non-equilibrium Statistical Mechanics*, by C. Van Vliet (World Scientific, 2008);  
*A Modern Course in Statistical Physics*, by L.E. Reichl (Wiley, 2009);  
*Statistical Mechanics in a Nutshell*, by L. Peliti (Princeton, 2011);  
*Statistical Mechanics and Thermodynamics: A Practical Approach*, by Cass Sackett (Zero K Press, 2019).
- Lectures: Tuesday, Thursday, 9.30 – 10.45 a.m., Robeson 122.  
Lecture notes will be posted on Canvas. I expect students to participate regularly, ask questions, and contribute to the class discussions.  
The Virginia Tech Principles of Community apply to the entire course.
- Office hours: Monday, 1.25 - 2.15 p.m. and Thursday, 11.00 a.m. - 12.15 p.m.,  
Hahn Hall North 300.
- Homework: Problems will be assigned weekly, due by Tuesdays at 9.30 a.m.  
I encourage teamwork for solving the homework assignments, but solutions must be handed in separately.  
Should you encounter difficulties, please feel free to ask me for help.  
Using sample solutions or AI tools of any kind is *not* allowed.  
Your work will be graded, and my solutions will be posted on Canvas.
- Teaching assistant: Sara Shabani, sarashabani@vt.edu.

- Exams: Midterm test: Thursday, February 15, 9.30 a.m., Robeson 122.  
 Final exam: Friday, May 3, 7.45 - 9.45 a.m., Robeson 122.  
 The graduate honor code applies to all homework assignments, the midterm test, and the final exam, and will be strictly enforced.
- Grade distribution: 30 % homework, 30 % midterm, 40 % final exam.
- Course content: Statistical mechanics bridges the gap from the microworld, as described by quantum mechanics, to the *macroscopic* properties of many-particle ( $N \sim 10^{24}$ ) systems. Fortunately, once we take recourse to statistical methods, we can take advantage of the fact that in the *thermodynamic limit*  $N \rightarrow \infty$  the associated probability distributions typically become extremely sharp, and average quantities suffice for a quantitative description. Statistical mechanics thus not only provides a foundation for thermodynamics and the properties of gases, but generally for condensed matter in the form of fluids, glasses, crystals, semiconductors, superconductors, polymers, biomaterials, etc. Its concepts find broad applications in astrophysics, geophysics, particle physics, chemistry, biology, and engineering science.
- List of topics:
1. Fundamentals.  
Probability theory; ensembles: classical and quantum statistics.
  2. The microcanonical ensemble.  
Entropy; irreversibility; laws of thermodynamics (derivation); applications: paramagnet, ideal gas.
  3. The canonical and grand-canonical ensembles.  
Partition function, free energy; classical limit; grand potential; Gibbs–Duhem relation; applications: oscillators, gases.
  4. Thermodynamics.  
Thermodynamic potentials and processes; phase equilibria; dilute solutions; chemical reactions.
  5. Ideal quantum gases.  
Quantum many-particle systems; degenerate Fermi systems; photons and phonons; Bose–Einstein condensation.
  6. Interacting systems.  
Virial expansion, real gases; ferromagnetism, mean-field theory; phase transitions: scaling, renormalization group.
- Notice: Contact me if you require any adaptations or accommodations because of a documented disability, or to share emergency medical information.