PHYSICS 5705 — STATISTICAL MECHANICS
Syllabus — Spring 2018

Instructor:	Uwe C. Täuber
Office:	Robeson 109
Phone:	(540) 231-8998
Email:	tauber@vt.edu
Office hours:	Monday, 1.15 - 2.00 p.m.; Thursday, 11.00 - 11.45 a.m.

Recommended texts: *Statistical Mechanics*, 2nd ed., by F. Schwabl (Springer, 2006); *Statistical Mechanics*, 2nd ed., by R.K. Pathria (Butterworth-Heinemann, 1996).

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).

Lectures: Tuesday, Thursday, 9.30 – 10.45 a.m., Robeson 116.

Homework: Problems will be assigned every week, due on Tuesdays. 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 (during office hours, the discussion meeting, or via email). Using sample solutions of any kind is *not* allowed. Your answers will be graded, and my solutions will be posted.

Exams: Midterm exam: Thursday, March 1, 9.30 – 10.45 a.m.
Final exam: Tuesday, May 8, 10.05 a.m. – 12.05 p.m.
The graduate honor code applies to all homework assignments, the midterm, and the final exam.

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* $N \to \infty$ 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:	If you require any adaptations or accommodations because of a documented disability, if you need special arrangements in case the building must be evacuated, or if you have emergency medical information to share with me, please contact me as soon as possible.