

Physics 540: Statistical Mechanics, Fall, 2026

Instructor: Prof. R. Shrock, email: robert.shrock@stonybrook.edu

Tue.-Thu. 9:30 - 10:50 AM, Staller 3220

Office hrs. - by appointment; use email.

Recommended preparation: an undergraduate course in statistical mechanics

Textbook: The course will mainly use lecture notes and free online information resources. Although we will not follow any one textbook closely, a useful auxiliary book is H. E. Stanley, *Phase Transitions and Critical Phenomena*.

Course requirements are: homework, midterm, final exam, and class participation, weighted as follows: homework: 25 %, midterm: 30 %, final exam: 40 %, class participation: 5 %.

This course will cover statistical mechanics, including topics in the list below:

- General thermodynamics and statistical ensembles.
- Phase transitions and critical phenomena: examples with liquid-gas-solid systems and magnetic systems; experimental data; phase diagrams; order of transition; critical singularities in thermodynamic functions.
- Analysis of some models, including Ising, q -state Potts, $O(N)$ vector models; exact solutions for 1D cases; transfer matrix method.
- Ginzburg-Landau theory and mean field theory.
- Modern theory of second-order phase transitions: renormalization group (RG); universality classes and critical exponents; scaling relations.
- Approximate methods: high-temperature and low-temperature series expansions; low-density series expansions, Padé approximants.
- van der Waals and other equations of state; superheating and supercooling.
- Monte Carlo simulations.
- Quantum statistics: Fermi-Dirac and Bose-Einstein distribution functions and applications to phonons, photons, Bose-Einstein condensation; superconductivity and superfluidity.

If time permits, the course may cover some additional topics, including topological phase transitions, liquid crystals, orientational ordering, percolation transition, and the Lee-Yang-Fisher complexification program.

Learning goals: Students will gain (i) an understanding of the principles and methods of modern statistical mechanics (SM); (ii) familiarity with models used in SM; and (iii) a working knowledge of applications of SM.

The following information is required on all course syllabi by the university. Note the new university rules on use of artificial intelligence (AI).

Student Accessibility Support Center Statement:

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, Stony Brook Union Suite 107, (631) 632-6748, or at sasc@stonybrook.edu. They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

Academic Integrity Statement:

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology and Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at [http://www.stonybrook.edu/commcms/academic\(integrity\)/index.html](http://www.stonybrook.edu/commcms/academic(integrity)/index.html). A new requirement is to read and obey the university rules concerning the use of artificial intelligence (AI) for coursework.

Critical Incident Management:

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of University Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.

See <http://www.stonybrook.edu> for additional general university course rules.