Physics 541: Advanced Statistical Mechanics Spring, 2022

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

Mode of Lecture Delivery: This will depend on the COVID situation in the spring.
Meeting Time/Place: first meeting: Mon. Jan. 24, 11:45 AM. If the mode is in-person or hybrid, then the room location is to be announced.
Technical: This depends on the mode of lecture delivery.
Office hrs. - by appointment; use email.

Recommended preparation: PHY 540 or equivalent course.

Textbooks - We will not follow any one book, but will provide references to several recommended books and articles throughout the course.

Course requirements include homework, class participation, and a possible final exam. If a student has an A on the homework at the end of the semester, the final exam will be waived for that student. For students who do take the final, the grade weighting is: 50 % (homework), 10 % (class), 40 % (final).

This course will cover modern statistical mechanics, including a subset of the topics in the list below (in different years we will cover a different subsets of topics)

- Brief review of thermodynamics and discussion of 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; correlation length.
- van der Waals theory of liquid-gas transition; mean field theory and Ginzburg-Landau theory.
- Analysis of some models, including Ising, q-state Potts, O(N) vector, and ice models; exact solutions for 1D and quasi-1D cases; transfer matrix method.
- Potts model and connection to Tutte and chromatic polynomials in graph theory; ground state entropy
- Modern theory of second-order phase transitions: renormalization group; universality classes and critical exponents, dependence on spatial dimensionality and symmetry group of Hamiltonian; scaling relations, upper and lower critical dimensionalities; conformal algebra.
- Approximate methods: high-temperature and low-temperature series expansions, low-density series expansions, Padé approximants, Monte Carlo simulations
- Quantum statistics: Fermi-Dirac and Bose-Einstein distribution functions and applications to phonons, photons, Bose-Einstein condensation.
- Other types of phase transitions, e.g., Kosterlitz-Thouless, transition, liquid crystals and orientational ordering.
- Lattice field theory and connections with quantum field theory

- Methods of energy generation and options for reducing production of CO_2.

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 and connections with condensed matter physics and quantum field theory.

The following information is required on all course syllabi by the university:

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(underscore)integrity/index.html

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 and COVID policies,including vaccinations, COVID testing, and mask mandate.