STATISTICAL MECHANICS (PHY 540) Fall 2020
[http://tonic.physics.stonybrook.edu/~syritsyn/phy540_fall2020]

Important Note: Every effort will be made to avoid changing the course schedule, but the possibility exists that unforeseen events will make syllabus changes necessary. It is your responsibility to check the course website and Blackboard for corrections or updates to the syllabus. Any changes will be clearly noted in course announcements or through Stony Brook email.

Course title:	**Statistical Mechanics (PHY540)**
Credit:	3 units
Semester:	2020 Fall
Instructor:	Sergey Syritsyn (office C-140) sergey.syritsyn[at]stonybrook.edu
Lectures:	Javitz Lecture Center #102; 28 lectures starting Aug 25, TUTH 8:00-9:20am
Office hours:	Tuesdays 10:00am-12:00pm, Physics C-140
Lecture Notes:	will be posted online
TA & Grader:	TBA

Main textbooks (recommended reading):

1. L.Landau and E.Lifshitz, Statistical Physics, Pt.1, 3rd ed; ISBN:0750633727.
2. K. Huang, Statistical Mechanics, 2nd ed; ISBN:0471815187.
3. K.Likharev, "Essential Graduate Physics" [http://commons.library.stonybrook.edu/egp/5].

Course description: Brief review of thermodynamics, principles of physical statistics, systems of non-interacting particles: Boltzmann, Fermi-Dirac, and BoseEinstein statistics. Applications to ideal gases, electrons and phonons in solids, and black body radiation. Approximate treatment of nonideal gases. First-order and second-order phase transitions. Ising model, transfer matrix, and renormalization group approach. Fluctuations in thermal equilibrium, fluctuation-dissipation theorem, brief review of non-equilibrium fluctuations. Basic notions of ergodicity, classical and quantum chaos.

Course delivery:	in-person lectures, weekly homeworks, one midterm and the final exam
Homeworks:	weekly, due in class or electronically, deadlines 1 week after handouts, grades & solutions available next week
Exams:	TBA (either in-class with open books, or take-home)
Course grading:	Homeworks: 30%, Midterm: 30%, Final exam: 40%

SYLLABUS

1. Introduction and Review of Thermodynamics

Basic notions of statistical physics and thermodynamics: energy, entropy, temperature, work and heat. Thermodynamic potentials and circular diagram. Heat capacity and equation of state. Thermodynamics of ideal gas. Systems with variable number of particles and chemical potential.

2.Principles of Physical Statistics

Statistical ensembles and ergodicity. Probability, probability density, and density matrix. Microcanonical ensemble and the basic statistical hypothesis. Definition of entropy and relation to information. Canonical ensemble and the Gibbs distribution. Statistics of quantum oscillator, photons and blackbody radiation, phonons and heat capacity of crystals lattices. Grand canonical ensemble and distribution. The Boltzmann, Bose and Fermi distributions in systems of independent particles.

3. Ideal and Weakly Interacting Gases.

Thermodynamics of ideal classical gas and the Maxwell distribution. The Gibbs paradox. Quantum ideal gases, the Fermi sea and the Bose-Einstein condensation. Gases with weakly interacting particles.

4.Phase Transitions

First order phase transitions, phase equilibrium, latent heat, critical point, the Gibbs rule. The van der Waals equation. The Clausius-Clapeyron formula. Weak solutions, osmotic pressure. Second order phase transitions, the order parameter, critical exponents. Landau's mean field theory and the Ginsburg criterion. The Ising model, 1D solution via transfer matrix, Onsager's solution for 2D case. Numerical Monte Carlo methods, the Metropolis and the “heatbath” update algorithms. Renormalization group.

5. Fluctuations and Dissipations

Small fluctuations, variance, r.m.s. fluctuation. Fluctuations of energy and the number of particles. Fluctuations of temperature and volume. Time dependence of fluctuations, their correlation and spectral density. The fluctuation-dissipation theorem. Quantum noise and the uncertainty relation. The Einstein-Smoluchowski equation, the Fokker-Planck equation.

6. Elements of Kinetics

The Liouville theorem; the Boltzmann equation; the relaxation time approximation. Conduction of degenerate Fermi gas, electrochemical potential, thermoelectric effects, the Onsager reciprocal relations.