PHYS 438/538: Phase Transitions and Renormalization-Group Theory
Correlations, Criticality, Universality, Current Research Topics

First class: Tuesday 27 September
Tues 16:40 - 19:30 Room: FENS G015
A. Nihat Berker Rektörlük 216-483-9011
nihatberker@sabanciuniv.edu
Problem Session by Tolga Çağlar, time and place to be determined.

Office            Phone                 Office Hour*
Tues 16:40 - 19:30 Room: FENS G015   A. Nihat Berker Rektörlük    216-483-9011   Mon 4:30-5:30
nihatberker@sabanciuniv.edu, http://myweb.sabanciuniv.edu/nihatberker

*Office consultation can also be done on a drop-in basis or by appointment. Do call us!

Students and listeners, from SU and from other Universities, are welcome.
Shuttle services are available from and to Kadıköy and Taksim.

Prerequisite: Elementary statistical mechanics. If you know (or can quickly look up) what a partition function is and you are interested, you can take the course.

Students successfully completing the course may be given an original research problem.


The students will learn the remarkable phenomena occurring at phase transitions that are universally applicable to a wide range of systems, and simple and physically intuitive theory for deriving these phenomena. The dialog between experiment and theory, as well as the rich confluence of the intuitive, phenomenological, approximate, rigorous, and numerical approaches, will be illustrated.

1. Introduction: phase diagrams, thermodynamic limit, critical phenomena, universality.
2. Classical theories: naive mean-field, constructive mean-field, Landau theories; Ginzburg criterion.
3. Ising models and exact results: one dimension; two dimensions; duality; global phase diagrams.
4. Scaling theory of Kadanoff.
5. Exact renormalization-group treatments in one dimension.
6. Approximate renormalization-group treatments in two dimensions.
   Thermodynamic functions and first-order phase transitions.
7. Momentum-space renormalization group: Gaussian model, Landau-Wilson model, \( \varepsilon \)-expansion.
9. Dynamics: stochastic models; detailed balance; dynamic universality classes.
11. Surface systems. q-state Potts and Potts-lattice-gas models.
   Exact critical and tricritical exponents. Helicity and reentrance.
   Scale-free and small-world networks. Connection between geometric and thermal properties.
   High Tc superconductivity. Electron-exchange induced antiferromagnetism. Reverse impurity effects on antiferromagnetism and superconductivity.

Grades: midterm 25%; final 25%; weekly quizzes 25%; homework 25%.

If your homework average is at least 50/100, the lowest two quiz grades will be thrown out.