SABANCI UNIVERSITY
Faculty of Engineering and Natural Sciences       Fall Semestre 2010

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

First class: Tuesday 5 October
Tu 16:40 - 19:25 Room: FENS L063
Office           Phone                   Office Hour*
A. Nihat Berker Rektörlük  216-483-9009 Mon 4:30-5:30
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Problem Session at Sabancı U Wd 17:40 - 19:00, room to be announced, by Efe İker
Problem Session at Bosphorus U Wd 17:40 - 19:00, room to be announced, by Ahmet Demir
Problem Session at Koç U Wd 17:40 - 19:00, room to be announced, by Ozan Saryer

Problem session hours may be modified, at each University, to accomodate the schedule of the students.
*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 available from Bosphorus U and Koç U; from and to Kadıköy, Üsküdar, 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.


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.