Physics 518, Critical Phenomena and Field Theory
Syllabus Fall 2005

Instructor:

Prof. Jinwu Ye,
Office 315 Davey Lab
Phone: 863-5345
E-mail: jye@phys.psu.edu

Time and Location:

9:45 am-11:00 am, Tuesday and Thursday
207 Osmond.

Office hours:

Anytime

Pre-requisite:

Physics 517, 563

Reference Book:

P. M. Chaikin and T. C. Lubensky, Principles of Condensed Matter Physics

Grading information:

There will be 5 homework sets and a final take home exam.
A letter grade will be given as your final grade

Tentative Schedule:

Part I: Ginsburg- Landau theory, mean field theory and fluctuations

1. Order parameter, Symmetry breaking, critical exponents
2. Mean Field Theory, Fluctuations, Two-point correlation functions, Fluctuation-Dissipation theorem
3. Broken symmetry, Goldstone Modes, Mermin-Wegner theorem
4. Ginsburg-Landau Theory, Ginsburg Criterion
5. First order Transitions, hysteresis, meta-stable states, supercooling and superheating

6. Multi-critical points: Bi-, Tri-, Tetra-Critical points, Lifshitz points

Part II: Scaling and Renormalization group in momentum space

1. Critical exponents, Kadanoff's scaling, Scale invariance, Symmetry and Universality class
2. Wilson Renormalization Group in **momentum space**, Fixed points, $4 - \epsilon$ expansions
3. Large N expansion

Part III: Renormalization group in real space and duality transformation

1. Transfer Matrix Method in one dimension
2. **Real Space** Renormalization group in one and higher dimensions.
3. High temperature and low temperature series expansions, Duality transformation
4. Ising Model, Ising Lattice gauge theory, duality

Part IV: Topological phase transitions

1. Non-linear sigma model, $2 + \epsilon$ expansion.
2. Topological defects, Kosterlitz-Thouless Transition
3. 2-dimensional melting transitions, elasticity, translational and orientational order parameters, dislocations and disclinations, hexatic phase

Part V: Introduction to Quantum Phase Transitions

1. Bose-Einstein condensations, weakly interacting Bose gas, dilute Bose gas
2. Superfluid He4, Supersolid
3. Superfluid He3, p-wave pairing, B phase (BW state); A phase (ABM state); A1 and A2 phases.
4. Quantum anti-ferromagnet to paramagnet transition
5. Superconductor to insulator transition
6. .....