Syllabus for the qualifying exam on statistical mechanics

(not the syllabus for PHYS 219)

- Thermodynamics
  - The zeroth, first, and second law
  - Carnot engines
  - Entropy
  - Equilibrium and thermodynamic potentials
  - Stability conditions
  - The third law
- Probability
  - Random variables
  - Probability distributions
  - Many random variables
  - Sums of random variables and the central limit theorem
  - Rules for large numbers
  - Information, Entropy, and Estimation
- Kinetic theory of gases
  - Liouville's theorem
  - The Boltzmann equation
- Classical statistical mechanics
  - The microcanonical ensemble
  - Finite-level systems (2, 3- state systems)
  - The ideal gas
  - Mixing entropy and the Gibbs paradox
  - The canonical ensemble
  - The Gibbs canonical ensemble
  - The grand canonical ensemble
  - Fluctuations in ensembles and relation to susceptibilities
- Quantum statistical mechanics
  - Fermi and Bose Distributions
  - Black-body radiation
  - Hilbert space of identical particles

- Canonical formulation
- Grand canonical formulation
- Degenerate Fermi gas, Sommerfeld expansion
- Degenerate Bose gas, Bose condensation and Superfluid He^4

- Interacting particles
  - The cumulant expansion
  - The cluster expansion
  - Second virial coefficient and van der Waals equation
  - Breakdown of the van der Waals equation
  - Mean-field theory, Phase transitions (1^{st} and 2^{nd} order), critical behaviour, Exponents
- Statistical fields
  - The Landau theory of 2^{nd} order phase transitions
  - Saddle point approximation and mean-field theory
  - Discrete symmetry breaking and domain walls, energy entropy arguments of Landau Lifshitz and Peierls domain wall entropy
  - Exact solution of 1-d Ising model, transfer-matrix formulation
- Fluctuations
  - Scattering and fluctuations
  - Correlation functions and susceptibilities
  - Fluctuation corrections to the saddle point