Reading List | Spring 2018

Rice Physics 526 | Statistical Mechanics & Thermodynamics

References are section numbers in **Pathria and Beale** unless otherwise indicated. You should read these *before* the corresponding lecture. Dates are subject to shift as the class progresses.

Note: **Kardar** refers to Kardar's *Statistical Physics of Fields*, **Pl-B** refers to Plischke and Bergerson's *Equilibrium Statistical Physics*, and **Sethna** refers to *Entropy, Order Parameters, and Complexity*, available from the author's website. If you don't have access to Plishcke and Bergerson's book, you can substitute the corresponding topics in Pathria and Beale.

Date		Reading	Topic
M	Jan 8	Sethna Chapter 1	What are statistical mechanics and thermodynamics? Emergence, universality, and scale invariance: the diffusion equation. Phases of matter.
W	Jan 10	Pl-B 1.1-1.2	Laws of thermodynamics. Differentials, reversible and irreversible processes. The fundamental thermodynamic relation.
F	Jan 12	Pl-B 1.3- 1.4	Legendre transform, thermodynamic potentials, Gibbs-Duhem
M	Jan 15	*no class: MLK day*	
W	Jan 17	Pl-B 1.6	Maxwell relations, stability, thermodynamic response functions
F	Jan 19	1.1-1.2, 1.4, 2.1	Review of probability theory. Microstates and microstate. Microcanonical ensemble: probability distribution, entropy. Ideal gas (microcanonical ensemble).
M	Jan 22	2.2-2.3	Foundations: Why (and when) is the microcanonical ensemble applicable? Liouville, ergodicity, "MaxEnt"
W	Jan 24	1.2	Deriving thermodynamics from statistical mechanics: Second law: why does entropy increase?
F	Jan 26	3.1, 3.3, 3.4	Subsystems: canonical ensemble. Derivation from microcanonical. Thermodynamic limit. Partition functions. Fluctuation-response relationship: uniform.
M	Jan 29	3.5, 3.7, 4.1. Goldstein *Classical Mechanics, 3rd edition* 3.4	Partial traces. Grand canonical and other thermodynamic ensembles in statistical mechanics and thermodynamics: Laplace and Legendre. Equipartition and virial theorems.
W	Jan 31	4.3, 4.4, 4.7, 6.6	Grand canonical and other ensembles. Chemical reactions. Thermodynamics of phase transitions (coexistence lines)
F	Feb 2	5.1, 5.2, 5.3	Micro and canonical ensembles in quantum mechanics. Density matrix. When is quantum important?

M			Feb 5	5.4, 5.5, 6.2	Indistinguishable particles. Number basis. Third law of thermodynamics.
	W		Feb 7	6.3, 7.4, 7.3	Statistics of occupation numbers. Non-interacting massless bosons: photons, phonons.
		F	Feb 9	*no class: spring recess*	
M			Feb 12	7.1, 7.2	Non-interacting massive bosons: Bose-Einstein Condensate
	W		Feb 14	8.1, 8.2. Skim 8.3-6	Ideal (spinless) Fermi gas. Spin-1/2 Fermi gas. Applications: metals, white dwarfs – universality!
		F	Feb 16		open discussion
M			Feb 19	12.3, Sethna 8.3	Interacting systems. Lattice spin models, Ising model. Phases, adiabatic continuity, and phase transitions.
	W		Feb 21	12.4, 13.2	Liquid-gas transition. Symmetry breaking and order parameters in Ising model. Exact solution of 1D Ising.
		F	Feb 23	13.2	Thermodynamics and correlations of 1D Ising mode. Phase transitions are beyond perturbation theory. More general cases?
M			Feb 26	12.5, 12.7 skim 12.6	Mean-field theory. Symmetry breaking & order parameters revisited. Classifying phases of matter. Critical exponents.
	W		Feb 28	12.9	Landau theory: universality. First-order vs continuous phase transitions.
		F	Mar 2	12.10, 12.11, 12.13	Can we trust mean-field? Ginzberg criterion (heuristically), scaling hypothesis
M			Mar 5	16.1-2	Numerical methods: Monte Carlo to do statistical sums and integrals. Detailed balance, Markov chains.
	W		Mar 7	16.5	Monte Carlo: critical slowing down and other limitations, data analysis and finite size scaling
		F	Mar 9	Kardar 2.1-3. Sethna 9.1-2	Landau-Ginzberg theory. Linear response theory (static): correlation-response relationship.
M			Mar 12	*no class: spring break*	
	W		Mar 14	*no class: spring break*	
		F	Mar 16	*no class: spring break*	
M			Mar 19	Kardar 2.4, 3.2. Sethna 9.3.	Landau-Ginzberg for XY model. Goldstone modes: dominate low-energy fluctuations.
	W		Mar 21	Kardar *SPOF* 3.3, 2.5	Stability of order, two results: “No 1D order at T>0” and “No continuous symmetry breaking in d<=2” (Mermin-Wagner)
		F	Mar 23	3.5, 3.7	Deriving Ginzberg criterion: when can MF capture the critical point? Fluctuation-response: non-uniform, static.
M			Mar 26	Sethna 9.4	Topological defects (dynamically persistent excitations)
	W		Mar 28	Kardar 4.1, 4.2	Scaling, homogeneity, universality.
		F	Mar 30	14.1, Kardar 4.4, 4.5	Conceptually explaining scaling: renormalization group. Gaussian integrals
M			Apr 2	Kardar 4.6, 4.7	Renormalization group: noninteracting (Gaussian) model
	W		Apr 4	Kardar 5.1, skim 5.2-5.4	Renormalization group for Ising model, expectation values in the Gaussian model. Perturbation theory diverges!
		F	Apr 6	skim Kardar 5.5-5.7	Perturbative RG: a sketch

M	Apr 9	14.3, Kardar 5.8, 5.9	Understanding and using RG flow equations: relevant and irrelevant variables, obtaining critical exponents.
W	Apr 11	15.6, Sethna 10.8	Near-equilibrium dynamics: linear response, fluctuation-dissipation
F	Apr 13	Sethna 10.9	Causality and Kramers-Krönig. Far-from-equilibrium: rate equations
M	Apr 16	15.3	Far-from-equilibrium: rate equations and stochastic differential equations
W	Apr 18	15.4, skim Kardar 9.5	From stochastic differential equations to Fokker-Planck. Nonequlibrium Landau-Ginzberg
F	Apr 20	Jarzynski PRE 56, 5018 (1997) Secs I and II	Beyond the core statistical mechanics: strengthening the 2nd and 3rd laws: Jarzynski equality and bounds on efficiency of cooling.