

## Material for Week 8

Physics 4488/6562: Statistical Mechanics

<https://sethna.lassp.cornell.edu/Teaching/562/>

Exercises due Mon. Mar 17

Last correction at January 27, 2025, 2:25 pm

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On Wednesday, you will be running simulations during class. They should run on laptops, tablets, or smart phones.

### Monday

In-class question: [7.24](#) *Is sound a quasiparticle?*

### Wednesday

Read: Chapter 8, Sec. (8.1) (The Ising model)

Pre-class question: [8.16](#) *Ising hard disks*

In-class question: [8.1](#) *The Ising model*

In-class question: [8.17](#) *Ising parallel updates*

### Friday

Read: Chapter 8, Sec. 8.2 (Markov Chains)

Pre-class question: [8.3](#) *Coin flips and Markov*

In-class question: [8.5](#) *Detailed balance*

### Monday

Read: Chapter 8, Sec. 8.3 (What is a Phase? Perturbation theory)

Pre-class question: [8.18](#) *Ising low temperature expansion*

## Assigned exercise for everyone

- 7.1 *Ensembles and quantum statistics.* Harder than you expect. Don't be misled by the multiple choice format. I had to do a complete solution to answer some of the questions

## Special topic exercises (6562 do one; 4488 do 7 during 14 weeks)

- 8.20 *Unicycle.* What detailed balance prevents.
- N1.24 *Distinguished and undistinguished particles.* Deriving MB statistics by ignoring differences between particles.
- 7.15 *The photon-dominated Universe.* (Astrophysics) The echo of the Big Bang is a Planck distribution.
- 7.21 *The greenhouse effect.* (Astrophysics, Ecology) Why the Earth is hotter than one would guess.
- 7.14 *Bose condensation: the experiment.* (Quantum, Atomic physics) Analyzing the 1995 experiment first showing Bose condensation.
- 7.12 *Semiconductors.* (Quantum, Condensed matter) A caricature model for electrons and holes in a semiconductor.
- N5.20 *Averaging over disorder.* Glass physics and the replica trick (Parisi won the 2021 Nobel by breaking replica symmetry and using it to explain lots of disordered systems).
- 7.16 *White dwarfs, neutron stars, and black holes.* (Astrophysics, Quantum) Cold stars don't collapse because they are made of fermions – until they get too massive. Fermi pressure vs. gravity.
- 7.26 *Entanglement of two spins.* (Quantum) Throwing away part of a system increases its entropy. Entanglement with an unobservable state.
- 8.2 *Ising fluctuations and susceptibilities.* (Computation) The response to a field is proportional to the spontaneous fluctuations. Test this using Bierbaum's "ising.js" simulation. Fluctuations and susceptibilities in the Ising model.
- 8.4 *Red and green bacteria.* (Mathematics, Biology) Try analyzing the extinction rate, this time with Markov chains.
- N1.32 *Polyacetylene and solitons: weird quasiparticles.* (Condensed matter) Quasiparticles with spin-charge separation. The first topological insulator. Hints at <https://sethna.lassp.cornell.edu/StatMech/EOPCHintsAndMaterials.html>
- 7.27 *Heisenberg entanglement.* Entanglement and the eigenstate thermalization hypothesis. Entanglement entropy between subsystems of a manybody correlated electron state. Hints at <https://sethna.lassp.cornell.edu/StatMech/EOPCHintsAndMaterials.html>
- N4.43 *Supersymmetric harmonic oscillator.* (Quantum, Supersymmetry) [Not technically stat mech], the simplest supersymmetric QM model.