Themes/Highlights of Phys 404:

Counting configurations (microstates) for given macrostate/energy; then entropy, T, etc.

Computing partition functions and using Z to generate other thermodynamic functions

Obtaining thermodynamic functions from each other, relations between them (and their derivatives), dependence on T, V, N, etc.

State variables vs. path-dependent quantities

Equipartition and counting quadratic modes

Equilibrium: meaning & usage

1st & 2nd laws of thermodynamics

Processes on p-V (or T-S) phase diagrams: isothermal, adiabatic, isobaric, isochoric, and what happens in cycles

Phase transitions, latent heat, critical point

Boltzmann and Boltzmann-Gibbs factors; canonical & grand canonical ensembles, Z & $\mathcal{Z}$

Understanding distributions, e.g. Maxwell speed, photon intensity in blackbody spectrum

Equations of state: ideal gas, van der Waals gas, paramagnet

Meaning of temperature, negative temperature; chemical potential μ and T dependence

Einstein vs. Debye models of lattice vibrations

Heat capacity at low T, what it reveals, T^n vs. $\exp(-\Delta/k_B T)$, generating other thermodynamic functions from C, finding equipartition result at high T

Finding and using the density of states of particles, photons, etc.; role of dimension; relation to g in Z summation

Metal (electron gas) at T=0 and at $T \ll T_F$, Sommerfeld expansion and how to use it

Reason for BEC; ideal Bose gas vs. trapped atoms

Ising model and mean field (& relations to paramagnets)

12/17/13