APh105c:
Critical Course Information

Spring 2006

1 Introduction

When: Th 8:30-10:30 and Fr 11-12.

Who: You and me (Rob Phillips, x 3374, *phillips@pboc.caltech.edu*, 159 Broad). The TAs for the course David Van Valen (vanvalen@caltech.edu, 155 Broad), Frosso Seitaridou (frosso@its.caltech.edu, 71 Broad) and Hernan Garcia (hgarcia@caltech.edu, 153 Broad). I am always happy to see you, but with certainty, the best way to contact me is by email. After that, the best approach is to schedule a time to see me through my assistant, Katie Miller (x6337, *kmiller@caltech.edu*).

Where: 104 Watson

What: Statistical mechanics as applied to problems of *current* interest from physics, materials science, molecular biology and chemistry. Special emphasis will be put on getting the dynamics back in thermodynamics.

How: Lecture twice a week and weekly homework. No exams. Your grades will be based upon your homework grades. I will NOT accept late homeworks (late means anytime after class is over the day the homework is due) unless you have a mindblowingly good excuse. As for collaboration with others, you may discuss the homework with others, but your explanations and derivations must be your own and your logic should be carefully explained

and the *significance* of your results should also be explained. If you hand us a sloppy homework the grader will likely be unable to penetrate your logic and you will lose points. Since grading is based strictly on homeworks, my standards are very high - if you don't turn in a top notch performance on every homework, you will likely not get an A.

2 Course Outline

Below I have tried to spell out the outline of the course as it would go if there were no time constraints. On the other hand, as we go along it may emerge that the way I have organized things is not optimal and we may elect to change direction. At any rate, this outline should provide you with one vision of the way in which thermodynamic thinking might be organized.

2.1 A Feel for the Numbers

- *The meaning of k_BT*
- *Energy Flux.* Numbers and Estimates. Evolution and the Age of the Earth.
- *Mass Flux.*

2.2 Statistical Mechanics as Inference

- *Information and Entropy.* A Feeling for the Numbers.
- *Principle of Maximum Entropy.*

2.3 Examples of the Calculus of Equilibrium

- *Chemical potentials: the crowned jewel of equilibrium statistical mechanics.* A Feeling for the Numbers.
- *Statistical mechanics and thermodynamics of interfaces.*

2.4 Putting the Dynamics Back in Thermodynamics: Beyond Equilibrium

- *Diffusion of Mass and Heat.* Brownian motion and dynamics of systems *in equilibrium*. Transport of mass, momentum and energy. Macroscopic evolution equations. Diffusion to capture. Diffusion-limited rates of reaction.

- *Field Theories of Material Systems.* Elasticity and hydrodynamics. Free energy functionals. Microstructural evolution in materials.

2.5 Beyond the Diffusion Equation

- *Smoluchowski, Fokker-Planck and Langevin.* A Feeling for the Numbers.

- *Linear Response Theory.*

- *Onsager and irreversible thermodynamics.* Small departures from equilibrium. Onsager relations.

2.6 Statistical Mechanics on Trajectories

RP: do some numbers estimating number of trajectories, etc.

- *Maxent Revisited.*

- *Principle of Maximum Caliber.*

3 Books I Have Liked

Thermal Physics by C. Kittel and H. Kroemer. This book is my favorite among the "conventional" thermal physics line up. They do not attempt to decouple statistical mechanics and thermodynamics (which is fine with me).

States of Matter by David Goodstein. This book is tied to OUR course which Goodstein has taught many times. The book is full of insights and

humor.

Thermodynamics and an Introduction to Thermostatistics by H. Callen. This book is being used in at least two other courses currently being offered at Caltech and I can see why. It really is a fine book with deep insights into the ideas giving rise to our modern conception of thermostatics.

An Introduction to Thermal Physics by Daniel Schroeder. This relatively new book is full of great examples. What endears this book to me above all is the emphasis on understanding real world problems rather than schoolboy exercises.

Quite frankly, the list I give above is relatively conventional and my preference is for books that are less pedagogical and which are taking risks to try and get to the bottom of how to build a fully dynamical theory of states of matter - some of the places you might look are: all the books of Truesdell (opinionated, scholarly, obnoxious, humorous), Zubarev, Mazenko's new series, the first two of four books have now hit the streets, Leo Kadanoff's fine **Statistical Physics** and many others. If you really care, we can talk.