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H. Gould and J. Tobochnik: Statistical and Thermal Physics

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Thermodynamics and Statistical Mechanics are traditionally taught in a one-semester course in most undergraduate physics programs. The unusual phenomenological approach of Thermodynamics and its almost philosophical arguments, coupled with the lack of a clear "canonical" curriculum for Statistical Mechanics, due to the vastness of topics available to choose from, make this one of the most problematic courses for students and teachers alike, and there exist relatively few, successful textbooks on the subject. Now, Harvey Gould and Jan Tobochnik bring in their expertise as active researchers in Statistical Physics and as editors of "The American Journal of Physics," as well as many years of dedication to exploring the role of computers in physics education and to teaching in general, to produce a remarkable textbook, "Statistical and Thermal Physics," that is sure to rapidly become a classic in this field.

As opposed to some textbooks, that expose and develop the two disciplines in tandem, Gould and Tobochnik discuss Thermodynamics first and only then broach the subject of Statistical Mechanics, minimizing the confusion that arises from shifting back and forth between the two main story lines. (Discussion and examples of how Statistical Mechanics connects to Thermodynamics are scattered throughout the second part of the book, nevertheless.) Chapter 1 motivates the study of both disciplines, with the aid of several examples that are discussed at a mostly intuitive level. Thermodynamics is then covered thoroughly in Chapter 2, starting from the most basic concepts and culminating with thermodynamic potentials and Legendre transforms. This rather lengthy chapter could form the basis of a course in its own right. The remainder of the book is devoted mostly to Statistical Mechanics. Chapter 3 provides a detailed introduction to probability theory, the central limit theorem, and other key ideas needed further on. The basic methodology of Statistical Mechanics is developed, meticulously, in Chapter 4. Chapter 5 discusses magnetic systems and the Ising and related models at quite larger depth and detail than most undergraduate textbooks. Much of the material traditionally covered in other textbooks, including the grand

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canonical ensemble, the various types of statistics and their application to black body radiation, phonons, metals and crystalline solids, etc., are discussed in Chapter 6. Chapter 7 deals with the chemical potential and phase equilibria, while Chapters 8 and 9 delve into more advanced material, often reserved for graduate level courses, including virial coefficients, cumulants and temperature expansions, the Landau theory of phase transitions, and the renormalization group method.

The book is peppered with numerous computer simulations. The programs are open source and are available in various formats, including as applets that can be run within a browser, and can be downloaded from the publisher's website and from the ComPADRE digital library at www.compadre.org/stp. The applets ran smoothly on my browser, though two versions are available and it took me some time to understand that only one of those offers the controls referred to in the text. The effort is more than worthwhile, since playing with the applets really does develop intuition and deepens understanding. Chapter 1, in particular, relies heavily on simulations, as the student is invited to experiment with the applets and much of the discussion revolves around these experiences. The simulations play a much less significant role throughout the remainder of the book, where they add to the story, though the text can be approached largely independently.

The book is self-contained and the requisite math is developed and explained on the go. The explanations are lucid and very detailed. New concepts and ideas are often introduced through sample problems and the student is guided through their solution in a spirit of self-discovery, fostering physical thought at its best. The authors go to great lengths to maintain a self-consistent, rational line of thought. For example, a whole section is devoted to emphasize the meaning of *probability* as a measure of one's degree of belief that an event could happen, as opposed to its more common definition as the observed frequency of a particular outcome. Such attention to detail is particularly helpful in teaching Thermodynamics, a subject rife with subtleties and concepts that are too easily misinterpreted.

The multitude of problems scattered throughout the book are one of its most appealing features. The problems are of two kinds: open-ended/thought provoking, and computational, and both kinds are necessary, to develop understanding and for mastering technicalities. Many of the problems appear in mid-text, to help clinch key ideas (some are solved in great exquisite detail), and many more are suggested at the end of each chapter. This format is exceptionally helpful for self-study. Many of the problems (as well as several designated sections) introduce topics and themes of interest in contemporary research.

If there is any fault to be found with the book, perhaps it is that it is too complete, overwhelming with details and a vastness of topics. Teachers might have to work hard to select a path and guide their students through a restricted subset of the many great topics covered. On the other hand, this very same quality makes it a fantastic self-study and reference book, one that I would not hesitate recommending to my colleagues and students, regardless of price.