

The book has been reviewed in three journals. The three reviews are transcribed below.

Review I: “Journal of Statistical Physics”, Vol. 109, Nos. 516, December, 2002

Thermal Physics-Entropy and Free Energies, J.C. Lee, World Scientific, Singapore, 2002

This book will not be everyone’s cup of tea, but I enjoyed reading it. As the author says in the preface it is written in a relaxed style and it makes use of frequent analogies between the thermal world and the human world. It is intended to be used as a supplementary text or as an introduction to the field. There are relatively few equations in the text, even though the author discusses an array of topics from the very elementary to the quite sophisticated.

Chapter 1, Introduction to Thermal Physics, contains the first view of the author’s technique in which he presents the analogy between the particles in an isolated system obeying the quasi-ergodic theorem and a driver driving at random through the streets of Hattiesburg (the author’s home) for an inordinate amount of time.

Chapter 2 contains some useful mathematics and a brief discussion of the central limit theorem. Chapter 3 discusses isolated thermal systems, concentrating on ideal gases and spin systems. The concept of micro and macro-states are introduced, and the peaks in distributions for large systems are emphasized. The fundamental thermodynamic variables and equations are introduced, and emphasis is placed on the entropy and how it changes. The thermodynamic equilibrium is related to traffic control systems. There are brief mention of rubber bands, colloidal suspensions, and negative temperatures for spin systems. The maximum entropy principle is a central focus.

Chapter 4 discusses closed systems and the canonical ensemble. The minimum free energy principle is introduced. There is a nice section criticizing the concept of entropy as a measure of disorder. Again, ideal gases and Ising models are used as examples. Chapter 5 discusses open systems and systems with variable volumes. Chapter 6 on energy vs. free energy makes the analogy between the surroundings and the system and a bank and a customer. Chapter 7 on phases and phase transitions contains the usual material in addition to surfaces and mixing and demixing.

Starting with Chapter 8 on second-order phase transitions, considerably more advanced concepts are introduced, including order parameters, universality, mean field theory, and Landau mean field theory. Static scaling theory is introduced. All of these are described with a minimum of mathematics and a maximum of insight. Chapter 8 on the Landau-Ginzburg free energy functional continues this trend and discusses the Cahn-Hilliard equation and renormalization group theory.

Finally, Chapter 10 on Monte Carlo and finite-size scaling is a simple but deep presentation of these concepts.

In all of these chapters, there are useful analogies presented relating the tendencies of systems to approach equilibrium with more mundane topics like relocating squirrels.

The author has been extremely successful in carving out his desired goals. The effect on potential readers is hard to assess, but I found the book entertaining and informative.

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Review II: “Contemporary Physics”, Volume 44, No. 2, Pages 187-188. (2003)

Thermal Physics: Entropy and Free Energies

By J. C. Lee, World Scientific Publishing Co., 2002

I liked this book. It is not a mainstream textbook, and is not intended to be one. The author's aim is to write in a relaxed and informal style, sketching over some details, but emphasizing key ideas that bring the whole subject into focus, making it more accessible and even fun. I can measure his success by the fact that I was reluctant to put the book down, which is hardly what I expected for a book in this subject area! The strength of the book is in giving readers an understanding of the basic principles of the subject and a sound intuition of the way thermal systems behave. This is done in a light way, but with absolutely serious intent. For example, we are encouraged to think of isolated systems as being driven by a relentless quest for entropy. The author then argues that $1/T$ can be thought of as an appetite for energy, and P/T an appetite for volume. In the same vein, μ/T is a measure of the extent to which molecules are driven away from a region. Too often, students manipulate symbols blindly, but are not quite sure what chemical potential, entropy and free energy mean. Well, here is a book to tell them.

Thermodynamics and statistical mechanics are used freely as part of a continuous argument, with no rigid divisions. For example, at a very early stage, the principle of equally likely microstates is used to derive the entropy of an ideal gas, using both phase space and energy eigenstates, in the microcanonical ensemble. This specific example is then used to motivate thermodynamic definitions that lead on to the first law of thermodynamics, the equation of state and the internal energy equation of an ideal gas. Fundamental statistical and thermodynamic concepts are immediately reinforced by a discussion of the Ising model, including a derivation of the entropy and Curie's law and discussions of fluctuations and negative temperatures.

In the canonical ensemble, the book carefully explains the effect of maximizing the combined entropy of system + reservoir. The ideal gas and the Ising model are again used as concrete examples, together with the photon gas and Einstein solid. The fluctuation-dissipation theorem is introduced although, as the author points out, this is really a misnomer for the zero-frequency relationships between fluctuations and static responses derived in the text—the fluctuation-response theorem might be a more suitable name.

In the grand canonical ensemble, the key idea of labeling microstates by the occupation numbers of quantum states is presented with minimal formalism, and illustrated by the Fermi-Dirac and Bose-Einstein gases and their classical limit. The discussion of these examples is astonishingly brief, given the richness of the material and the available experimental evidence. Still, the author is on a relentless quest for the big ideas of his subject, and has no time to linger over such details as Bose-Einstein condensation or the electron gas in solids or white dwarf stars. And who is to say he is wrong? Countless other books cover these subjects, and there is merit in restricting the focus to a few strong themes, within the confines of a slim volume. Helmholtz and Landau free energies are much closer to the heart of this book, and are explained with care; for example an explicit distinction is made between the free energy of a macrostate and the equilibrium free energy. The strong emphasis on intuitive understanding is also maintained here with, for example, $F/T = U/T - S$ being interpreted directly as a net entropy cost, where U/T is the entropy lost by the thermal reservoir and S is the entropy gained by the system. Parallels are drawn

between the multiplicity and the partition function, and the reader is shown why some Boltzmann factors include energies and others include free energies.

The last third of the book gives a lucid introduction to first- and second-order phase transitions. Topics discussed include the liquid-gas transition, the ferromagnetic transition, the van der Waals model, metastability, instability, spinodal decomposition, correlation lengths, critical exponents, scaling laws and universality. Landau mean field theory and the static scaling hypothesis are used as theoretical models. Most ambitiously, the Landau Ginzburg free energy functional is introduced, leading to the Cahn-Hilliard equation. At the end of the book, an overview is given of the renormalization group and of Monte-Carlo calculations. The student is challenged to write his or her own computer program to obtain some concrete results. This is a real challenge, as few hints are given.

I have a few quibbles. There is some unevenness in the assumptions made about mathematical knowledge. For example, the author reminds us of the Taylor series of exponential functions, but does not discuss the gamma function which he uses to find the surface area of a hypersphere in any number of dimensions. No distinction is made between functions and functionals, and functional differentiation is covered too briefly. There are a few places where the ordering seems odd, such as including the grand canonical ensemble in the same chapter as free energy and enthalpy in closed systems. I was also puzzled by the role of the appendices, including one on heat engines. No connection is made with the main text, and the material is presented as an afterthought. From his preface, the author clearly thinks that heat engines have had their day, and are a turn-off for students. I am not sure about this. I agree that they should not lead the discussion but they remain of great practical importance, and isn't it impressive that a physical theory can govern something as practical as a power station and as esoteric as the exponent of a correlation length near the critical point? Finally, it would have been nice to have more illustrations and some sample code for the final Monte Carlo calculations. Let me stress, however, that these are quibbles. I hope that advanced undergraduates will read this book. It should not be their first book on the subject—too many holes are left, for example, the special role of state variables is given no discussion— but non-beginners should find it both informative and enjoyable. Post graduates may also find this book useful in providing a rapid, almost pain-free introduction to the subject. At the very least, teachers will benefit by using some of the ideas in this book in their own lectures.

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Review III: "IEEE Electrical Insulation Magazine", Vol. 20, No.3, 65-66, May/June 2004.

Thermal Physics—Entropy and Free Energies, J.C. Lee, World Scientific Pub. Co., 2002

Although not one of the most exciting books—even by engineering standards— this book does provide a much better presentation than most text books that cover thermal physics, especially as

entropy and free-energy concepts are frequently just a chapter or two in a physics text. This book is entirely focused on the basic concepts of thermal physics, with the intent of making the reader understand the concepts of entropy and free energy and ultimately building up to the Landau-Ginzburg (LG) free energy functional.

The author's relaxed and informal writing style makes for better understanding of the subject matter. He uses many analogies between what happens in the thermal world and what occurs in the human world to reinforce the concepts. However, the reader should still have a good background in physics and quantum mechanics to use this text effectively. The book begins by introducing thermal physics in laymen's terms, and pertinent background information (energy eigenvalues, mathematical identities, Fourier transformations, and vectors and functions) is reviewed. Next, the concepts of entropy and free energy are described in detail for single isolated systems and systems in contact with thermal reservoirs. Other topics include energy versus free energy, phase transitions, and the LG free-energy functional. The LG model, widely used in condensed matter physics and materials science, is used to model the free energy level of things such as ferromagnets and mixing and demixing of binary systems.

This text could be useful as a crash course in thermodynamics for graduate students or for working professionals who never really learned this material while in school.

* The reviewer's name is not listed.
