The discussion of the Hamiltonian mechanics in Chapters 7 and 8 nowhere touches on the integral invariants, Pfaffian forms, action-angle variables and the Poisson brackets. All of these topics play a central role in the canonical transformation theory, and their exclusion deprives the reader of a balanced view of the subject.

Also ignored in the text is the perturbation method of Lie series, as developed by Genichiro Hori (1966) and André Deprit (1969). The method has certain advantages over the method of von Zeipel; in particular, it solves the problem of "inversion." In this light, the authors' judgment on page 228 that "... inversion becomes a tedious undertaking. Consequently, the merits of the Hamiltonian procedure in celestial mechanics have been subject to some *debate*" is no longer valid.

Not mentioned anywhere in the text is the crucial contribution of Kaare Aksnes to artificial-satellite theory. He improved (1965) the Garfinkel intermediary, thereby facilitating the calculation of the higher-order perturbations, and then used the improved intermediary to construct a complete second-order theory (*Astron. J.* **75**, 1066, 1970). Had the authors been aware of his work, perhaps their tentative remark on page 247 regarding the relative merits of the Vinti theory would be more definitive.

Misprints have been noted in equations (1.4.11) and (1.4.14) on pages 5 and 6.

Despite these flaws the book well serves the purpose of providing the fundamentals of perturbation theory for engineering applications. It is written in a clear and forceful style, and is a welcome addition to the growing literature of the field.

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Molecular Photoelectron Spectroscopy

By D. W. Turner, C. Baker,
A. D. Baker, C. R. Brundle
386 pp. Wiley, New York, 1970. $19.50

In 1962, David W. Turner and M. I. Al-Joboury demonstrated the feasibility of obtaining well resolved photoelectron spectra from molecules by irradiating gaseous samples with the 21.21-eV helium resonance line. Since those first experiments Turner and his coworkers, first at Imperial College, London, and more recently at Oxford, have accumulated a large number of spectra from the more loosely bound valence orbitals in small and medium-sized molecules. In this volume a systematic collection of these spectra is presented, and interpretations are discussed.

In molecular photoelectron spectroscopy monochromatic radiation is used to eject an electron from a neutral molecule M, leaving a unipositive molecule-ion M$^+$. If M is very small, its vibrational modes are not excited at ordinary temperatures, Thus the initial state can be regarded as simply the v = 0 vibrational level of the electronic ground state of M. Discrete spectra arise from photoelectrons that accompany transitions to bound final states in M$^+$. A spectrum consists of groups of peaks. Each group arises from a bound electronic state of M$^+$, and the peaks correspond to individual vibrational levels within that state. The Born–Oppenheimer approximation is applicable, and the individual vibrational components are modulated by Franck–Condon factors.

Photoelectron spectra offer considerable insight into chemical bonding. Not only can the binding energies of electrons from individual molecular orbitals be measured precisely, but the classification of each orbital as "bonding," "nonbonding" or "antibonding" can be inferred from the vibrational structure and characteristic frequency of its photoelectron spectrum, as the authors explain. Especially for small molecules the interpretation is quite straightforward, and this method yields valuable information that is not available from other techniques.
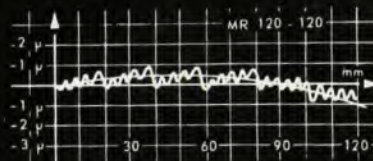
The book is divided into 14 chapters, with the first being a simple but necessary introduction to later chapters and the second describing experimental methods. Photoelectron spectra of molecules are discussed in the remaining chapters. Chapters 3–12 treat groups of similar molecules, roughly in order of increasing complexity, up to heterocyclic aromatic compounds. Chapter 13 is on HCN and related compounds and the last chapter deals with sundry inorganic compounds. Each chapter has the format: discussion of spectra; spectra; references. This arrangement is cumbersome if one is interested only in a particular molecule. However, it does help to emphasize the similarities that occur among a number of related substances.

In evaluating the quality of the book it should be remembered that the *contents* are of paramount importance, because they are unique. The spectra are excellent and well chosen. The discussions are terse and matter-of-fact, as befits a book that is 40% text and 60% spectra. I would have preferred fewer spectra, analyzed in more depth, but this is largely a matter of taste. The writing is generally quite clear. A num-

ber of minor errors slipped through in proofreading.

Two cautionary comments are in order. First, as the authors emphasize, the properties of the molecule-ion M^+, not those of M, are directly obtainable from a photoelectron spectrum. Comparisons with ground-state properties of M are therefore subject to the qualifications given by Koopmans' Theorem. Second, the utility of photoelectron spectroscopy in elucidating detailed properties of larger molecules is, in this reviewer's opinion, not yet well established. Within these limitations the technique can provide new information about any molecular species that can be brought into the gaseous phase. It should accordingly be of interest to anyone concerned with the chemistry or physics of small molecules.

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Thermophysics
By W. H. Giedt
594 pp. Van Nostrand Reinhold, New York, 1971. $13.95

This book is intended as a text for undergraduate students of engineering. The title *Thermophysics* was "selected to stress that this study embraces practically all branches of science and technology."

In the last ten years approximately 100 undergraduate thermodynamics books have been published in English (my count). The various pedagogical approaches in this rich collection are roughly as follows: classical or macroscopic; combination of classical and statistical; statistical alone, and emphasizing the connection between entropy and information theory. W. H. Giedt takes the now popular second approach in *Thermophysics*, stating that (the elaboration of) $S = k \log W$ provides a "physically reasonable explanation and definition of entropy as an equilibrium state property."

The book starts off ardently—the head for Chapter 1 ("Energy") runs:

"We are approaching the end of countdown.
All systems are go!
The ignition system is started.
All engines are running.
LIFT OFF! WE HAVE LIFT OFF!"

A short motivational discussion of rocket propulsion follows, focused on energy. The rest of the chapter outlines classical thermodynamics in an historical framework.

The first five chapters build up ideas such as internal energy, work, heat, equilibrium state and temperature more by accretion of examples than by formal development. Chapter 6 brings an abrupt change with the introduction of Schrödinger's equation in full bloom, followed by the elementary particle-in-box solution and cursory discussion of concepts such as phase space. Entropy is introduced as $S = k \log W$ in Chapter 7, and the statistical mechanics of ideal gases is discussed in the following chapter. Entropy change is treated in Chapter 9, the Gibbs equation suddenly appearing for the first time under "Gas Tables" on page 283. The remainder of the book may loosely be described as a wide variety of applications, including energy-conversion cycles, availability, Maxwell relations, chemical equilibrium in ideal gases, adiabatic flame temperature, and so on, each topic being rather briefly treated.

This is a serious effort to deal with a difficult and beautiful subject. There are many examples and exercises, primarily numerical. The historical annotation is often interesting (for example, according to the author the now cumbersome Fahrenheit temperature scale was originally pegged at 0 deg as the freezing point of a saturated salt solution and 100 deg as the temperature of the human body). The book is reasonably clear and accurate in its details. Unfortunately, the author has a distressing tendency to omit mentioning what are the basic irreducible principles and fundamental assumptions in his development. This leaves the student with a collection of material that needs to be taken somewhat on faith, but the articles of faith are unspecified.

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Lasers
By B. A. Lengyel
2nd ed. 386 pp. Wiley, New York, 1971. $14.95

Lasers, 2nd edition, is the third in a sequence of approximations by Bela Lengyel to the ideal introductory laser text. The first edition (1962—125 pages) was the first book on the market in which the uninitiated could get a realistic but comprehensible glimpse of laser theory and technique. It was followed three years later by *Introduction to Laser Physics* (1965—311 pages) which includes a chapter on the interaction of laser light with matter (nonlinear optics) as well as much more information on the theory of operation of various types of lasers. In his latest version, Lengyel has dropped the chapters on applications and nonlinear optics and returned to the earlier title.

The new *Lasers* shares with the earlier