The length of an arc of a circle is defined as the least upper bound of the set of real numbers representing the sums of the lengths of chords, after the existence of such a bound has been demonstrated. The concept of a path as the motion of a point travelling a directed distance along a circular arc is presented intuitively, and the values of the six trigonometric functions are specified by the coordinates of the terminal point of a standard path. Later it is shown that these functions may be expressed as functions of angles. The usual applications, including vector applications, are made.

The other elementary functions considered are the exponential and logarithmic functions. The laws of exponents are rigorously treated, and there is some logarithmic computation. Complex numbers and polar coordinates are discussed in appendices. Five-place common logarithm tables and four-place trigonometric tables are included.

The gifted, and interested, student should find this text stimulating and challenging as well as a source of considerable information not found in a conventional textbook on trigonometry. But the challenge may be too great for an unprepared instructor who could experience difficulty in motivating the author's treatment.

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Feynman as a Lecturer

The Feynman Lectures of Physics. Richard P. Feynman. Robert B. Leighton and Matthew Sands, Eds. Addison-Wesley, Reading, Mass., 1963. Unpaged. Illus. $8.75.

This book is based on the lectures given by Richard Feynman at California Institute of Technology during the academic year 1961 and 1962, and it covers the first year of a 2-year beginning physics course. The material consists essentially of the lectures as they were given by Feynman, the lectures being tape recorded, transcribed, and edited.

This is indeed a remarkable volume. On reading it, one is struck first by the extraordinarily extensive scope of the material contained therein, material which often takes one far afield from the conventional topics of the usual introductory course. As a result of this wealth of material, a certain conciseness is evident, but this lies primarily in the use of relatively few illustrative examples and not in any curtailment of the exposition of the basic physics. Reading this book is at times a breathtaking experience, and Feynman's style and special talent for exposition are evident throughout. Although the purpose of the course was to maintain the interest of the very enthusiastic and able students entering Caltech by presenting material taken from present-day physics, and this is done with boldness and depth, practically nothing in the older classical physics was neglected. In fact, the book appears encyclopedic in scope, and many topics related to other sciences and to engineering are dealt with in some detail.

Feynman states in his preface that he could see no " . . . reason to work the lectures in a definite order, in the sense that I would not be allowed to mention something until I was ready to discuss it in detail." The exercise of this degree of freedom, in my opinion, provided the book with one of its more attractive features. Feynman has shown clearly that it is not only possible but also rewarding to examine at some length the many rich implications of fundamental laws and ideas of physics before the maturity of the student allows an orderly derivation of such starting points. His elegant formulation of the law of electromagnetic radiation from an accelerated charge and its uses in a relatively detailed and extensive treatment of physical optics is a splendid example.

The reader must remember that the actual course consisted of section meetings and laboratory work as well as Feynman's lectures. One should really look at the problems (published separately in 1964 by Addison-Wesley) to appreciate what is expected of the students. Hence this book alone will not function well as a textbook, but as a reference for student and teacher alike, it is invaluable.

The general order of the material is as follows. After introductory chapters that describe physics in general and its relation to other sciences, the general subject of mechanics (including special relativity) is presented; this is followed by a relatively extensive discussion of electromagnetic radiation and physical optics. After a fairly brief introduction to quantum behavior, kinetic theory, and many of its applications, thermodynamics and wave motion are considered. The final chapter is devoted to symmetry and physical laws.

There are many items of special interest, but it would take far too long to describe them in any detail. The freshness of viewpoint, the accuracy of statement, the richness of the material, and the ingenuity of presentation—for example, the remarkable chapter entitled "Ratchet and pawl"—are striking. Reading this book will be a richly rewarding experience for all who desire to acquire a real understanding of what physics is all about as well as for students and teachers of physics.

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Mathematics

Lectures on General Algebra. A. G. Kurosh. Translated from the Russian edition (Moscow, 1960) by K. A. Hirsch. Chelsea, New York, 1963. 335 pp. Illus. $6.95.

Kurosh's book provides a coverage of the foundations of a good deal of what is treated nowadays under the title of modern or abstract algebra. The level of abstraction is, in general, that of Bourbaki's excellent works on algebra, though the terminology and notation frequently are rather different. In chapter 1, Kurosh deals with relations and sets; in chapter 2, he gives the basic properties of groups and rings and introduces the concepts of isomorphism and embedding; in chapter 3, he introduces the extremely general system of a universal algebra and also gives more results about groups, particularly groups with operators and free groups and rings. Chapter 4 is devoted to lattice theory with application to universal algebras and groups; chapter 5 gives an introduction to linear algebra from the general point of view of rings with operators and modules; chapter 6 introduces ordered and topological groups and rings and ends with a brief treatment of the Galois theory of fields.

As a text book, I feel that this volume would not be suitable for use in a first course in abstract algebra, except for a class of most unusual students, but it might well serve for a second course. Of course it is a superb reference book. Unfortunately, there are no exercises but there are occasional illustrative examples. The developments treated are clearly written and fairly easy to follow, although absorbing new concepts is always a fairly slow process; knowledge of at least a number of the basic ideas in abstract algebra is advisable for anyone wishing to go through the whole book.

The translation into English is better than that of most translated mathematical works which I have encountered. The typographical errors noted were obviously such and could easily be corrected by the reader.

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Mathematics

Elements of General Topology. D. Bushaw. Wiley, New York, 1963. viii + 166 pp. Illus. $6.95.

It is refreshing to discover a book which, in some 150 pages, transmits and unifies so many aspects of a basic branch of mathematics as does Bushaw's *Elements of General Topology.* The book is suitable for use in a one-semester course and the author's stated prerequisites of some knowledge of set theory and 3 years of sound undergraduate mathematics are realistic. After a leisurely, instructive, historical account, a well-motivated approach to a topology via axioms for open sets is followed by equivalent axiomatizations via neighborhoods, closed sets, closure, and later, subbases, bases, and neighborhood bases. Chapter 3, a brief treatment of continuity and homeomorphism, is followed by a discussion of subspace, product, quotient, and metric topologies (and later, uniformities), nicely unified by the observation that all are induced in a natural way by a function and a given topology (uniformity). T_i-separation and connectedness are discussed in chapter 5, along with equivalence in metric spaces and implications in general of Frechet, sequential, and covering compactness. A very clear proof of Tychonoff's product theorem is given. Bourbaki's influence, mentioned by the author, is evident. The concept of filters, rarely found in English texts, is clearly expounded and used in the chapters on uniform spaces and their completion (the last two chapters).

Bushaw has succeeded well in adhering to basic concepts with minimum distraction. His knack for choosing useful forms of effective results makes for easy reading and neat proofs. Involved proofs occur only in the last 20 pages, and many well-chosen examples and more than 200 graded exercises are spaced strategically throughout. Appendices include basic set theory, a bibliography, and hints or answers for some exercises. A minimum of errors—perhaps a dozen typographical, a couple of wrong formulas, and but one glaring error in an example (the latter on page 30) —and clear but informally stated definitions contribute to the readability of this text.

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Intermediate Textbook

Thermal Physics. Philip M. Morse. Benjamin, New York, revised edition, 1964. xiv + 455 pp. Illus. $10.50.

This book comprises the text materials used by Philip M. Morse in the course in thermodynamics and statistical mechanics which is required of senior physics majors at Massachusetts Institute of Technology. Those who are familiar with the preliminary edition published in 1962 will find this regular edition somewhat enlarged by the addition of a few topics, rewritten and improved in clarity, but essentially unchanged in choice of subject matter and order of presentation.

In *Thermal Physics* Morse undertakes to present, in three separate sections, ordered discussions of thermodynamics, kinetic theory, and statistical mechanics. No one can deal with all of these subjects in 400 pages, and the success of a text like this will depend on the degree of agreement between the author's preferences and those of the instructor and students who use the book.

Morse's preferences are clearly theoretical, and he places emphasis, in both text and problems, on ideas and algebraic development. There is virtually no discussion of experiments or experimental procedures bearing on the ideas, and actual data appear irregularly and in many cases approximately. Those who enjoy (or require) careful attention to the hard facts of experiment will find Morse's treatments disappointing; those who prefer horseback estimates in getting a feel for theory will be pleased.

The first third of the book is given to a conventional treatment of classical thermodynamics along historical lines. The discussion is concise, but Morse manages to include reasonable reference to the third law and a long section on helium II. It is pleasant to see attention paid to systems having more than two independent variables. But for a book oriented toward theory, some of the discussion is weak. There are, for example, no sharp definitions of such basic ideas as heat and internal energy. The treatment of the second law is based on Clausius and Kelvin, with no hint that modern alternatives exist for good reasons. Even within the Clausius-Kelvin limits, there is only casual discussion of the problem of approximating an arbitrary cycle by a set of Carnot cycles. The algebraic manipulations are done by the common elementary procedures (all too frequently opaque to students), without the simplicity and gain in conciseness available through the use of Jacobians. These are common characteristics of texts in thermodynamics; but they are not necessary in even a short treatment, and they mar a book newly written in the 1960's.

The second section, about 90 pages, discusses kinetic theory, chiefly of gases, but with some discussion of magnetic materials. It provides a very useful opportunity to introduce ideas of probability, phase space, distribution functions, and the like in the context of the rather specific kinetic theory model.

After a bow to classical statistical mechanics (Liouville's theorem), Morse develops a modern treatment of statistical mechanics by postulating the connection between entropy and the distribution function. This is then illustrated in a short chapter on the microcanonical ensemble and in extended discussions of the canonical ensemble, with applications to the theories of specific heat (including the Debye theory), the properties of gases, and paramagnetic materials. The grand canonical ensemble is introduced and is used to treat Einstein-Bose and Fermi-Dirac as well as Maxwell-Boltzmann systems. Tastes in statistical mechanics are individual, but Morse's choice of basic approach is defensible, and his treatment of it is excellent. Only the optional last chapter disturbs me; the student who has studied quantum mechanics will find little that is new, while the student who has not will find the discussion too concise to be instructive.