Book Reviews

Numerical Analysis. With emphasis on the application of numerical techniques to problems of infinitesimal calculus in single variable. Zdeněk Kopal. Wiley, New York, 1955. 556 pp. Illus. $12.

Numerical analysis is the science upon which the art of computing is based. Details of the art will vary with the computing device being employed—for example, abacus, slide rule, or Univac. However, the glamor of the electronic digital computers and their explosive propagation focus the attention on digital computation and lead to a restricted usage of the terms *computing* and *numerical analysis*. At any rate, most recent books whose titles include the words have little if anything to say about analog computers.

A digital device is designed to represent numbers as sums of powers of some base, in practice 2 or 10. Only a limited class of numbers can be represented exactly (for example, those expressible by ten decimal digits); others are only approximated. The device is further designed to perform only the four arithmetic operations, and the result can be exact in general only when it, as well as the operands, are all members of the limited class of numbers that are exactly representable. The output of a digital device is a finite set of numbers of the limited class. Thus a function, as such, is not a possible output, although a finite set of its functional values, or approximate values, would be.

Many problems of great practical importance, however (differential equations, integral equations), have a function, or several functions, among the unknowns. Such a problem must be somehow reduced so that a finite set of numbers will suffice. These numbers may be values of the function or functions at selected points. A somewhat more general approach is to set up a limited class of functions (polynomials, perhaps), which may or may not include a required function among its members, but from which one may hope to select a member that in some sense approximates the required function. The aforementioned reduction then amounts to finding a system of equations satisfied by those parameters which distinguish the approximating function (for example, the coefficients of an approximating polynomial) from among the others of its class.

Thus the problems for numerical analysis tend to stratify at two fairly distinct levels. At the higher, or secondary, level are the problems of reduction of functional equations to finite equations. At the primary level lie, however, the solution of these finite equations, along with the location of the extremes of functions, and the approximation of functions of rather general classes by functions of some fairly restricted class.

The areas concerned with equations, extremes, and approximations are not wholly distinct. In fact, the approximating function may be designated by parameters that satisfy a given set of equations, or minimize a given function, or both. Thus a separation is rather artificial, and reasonable justice can hardly be done to any one topic without some discussion of the other. Certainly a treatment of one of these topics to the exclusion of the others can scarcely justify being called "numerical analysis" without some qualification.

Nevertheless, Kopal's book, in spite of the general title, is in fact so restricted. It is true that the longish subtitle, which few will remember, gives warning that the contents are less general than the title. But even this, while excluding matrix theory and systems of equations, leaves open the possibility for including a consideration of the zeros and poles of functions of a single variable.

The book deals exclusively with polynomial interpolation, numerical differentiation and integration, and orthogonal polynomials, at the primary level; and, at the secondary level, with ordinary differential equations, including both initial-value problems and boundary-value problems, and with integral equations. An appendix discusses the use of Chebyshev polynomials for optimum-interval interpolation, but Chebyshev approximation (minimal departure) is not discussed.

Within the limited area there is, indeed, a great deal of material in the book. A brief history of numerical analysis provides an interesting introduction. Thereafter, two chapters on polynomial interpolation and numerical differentiation are followed by three on differential equations; and a chapter on mechanical quadrature is followed by one on integral equations. Noteworthy features are the sections on error in Chapters II and IV, the treatment of Runge-Kutta methods, the discussion of mechanical quadrature, the appendix on Chebyshev polynomials, the numerous problems, and the bibliography and notes.

The treatment is certainly not that of a mathematician; it is often prolix, sometimes confusing, and generally uninhibited by undue concern for rigor. As so often in books on the subject, the emphasis is on recipes and not principles. The phraseology is occasionally bizarre. Thus we are told that numerical analysis does not know of irrationals.

Problems in an area not treated are sometimes shrugged off as trivial. Thus, in the treatment of boundary-value problems, the author is careful to keep the matrices of low order, and we are told that (p. 284) once the characteristic values are known "the corresponding characteristic functions can be constructed without difficulty." The author then proceeds to "demonstrate the fact" by an example!

In brief, this is an excellent reference covering a limited area and might make a good textbook within that area, provided that it is consulted with circumspection or presented by an instructor who will fill the gaps.

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Combustion Processes. vol. II, **High Speed Aerodynamics and Jet Propulsion.** B. Lewis, R. N. Pease, and H. S. Taylor, Eds. Princeton University Press, Princeton, N.J., 1956. 662 pp. Illus. + plates. $12.50.

The purpose of this series and, in particular, of this volume is perhaps best expressed by the following quotations from the series editor and the volume editor. "Rapid advances made during the past decade on problems associated with high speed flight have brought into even sharper focus the need for a comprehensive and competent treatment of the fundamental aspects of the aerodynamic and propulsion problems of high speed flight." [This volume] "deals with rate processes in chemical reactions, the propagation of chemical reaction by the mechanism of combustion waves and detonation waves, with the effect of turbulence on combustion waves, with processes of simultaneous mixing and combustion of fuels and oxidants and with chemical equilibria."

One of the obvious difficulties confronting the volume editors was that there was already in existence an excellent book covering an important part of the subject written by one of their members. This problem was ingeniously solved by including "a condensed version of Chapter VII of the authors' [B. Lewis and G. von Elbe] book *Combustion Flames and Explosions of Gases.*" I would like to commend the editors on this decision; the material, which constitutes 96 out of the total of 662 pages, is certainly well worth repetition and, in fact, is a high point of the volume.

Another difficulty faced by the editors is the great diversity in the kind of material necessary to cover the subject. This material ranges from relatively simple and well-understood phenomena where theoretical analysis is powerful and useful to subjects so complicated and poorly understood that a survey of the state of the art is about all that can be accomplished. In general, the multiplicity of authors and corresponding points of view offers an acceptable solution to this problem, although it raises others. One finds, for example, that the author and the subject matter are not always ideally suited.

I found my blood pressure rising slightly when I discovered on page 27 that the outmoded and confusing concept of "friction work" is perpetuated. A subsequent author finds it necessary to square himself with the "friction work" concept by a footnote (page 208), which says: "Here, as is always the case, heat and heat flow are defined so as to complete the energy balance. A modification of the definition of work must be accompanied by a corresponding modification of the definition of heat flow." It is regrettable that such a footnote was necessary.

On pages 346 to 351, a section appears entitled "Turbulence generation by a turbulent flame" in which the author states that, "The intensity of the turbulence generated by the flame may be calculated from the amount of mechanical work developed by the gas as it flows across the pressure drop Δp of the instantaneous flame front *because* this work is the source of additional turbulent energy." (Italics are mine.)

The author notes that the work done by the expanding gas on the surroundings is not equal to $\int p d\left(\frac{1}{\rho}\right)$ and concludes that the discrepancy is the source of turbulence. If this were true, then it would follow that the flow behind any shock wave, where the same discrepancy exists, would show strong turbulence (which it does not). I suggest that it is necessary to look elsewhere for the source of flame-generated turbulence. It appears that the fundamental difficulty here is the failure to distinguish clearly between a flow process and a batch process, between a control volume and a system, between the Eulerian and the La Grangian point of view, however you wish to state it. It is unfortunate that the fine treatment of this problem which appears on pages 203 to 211 is concealed in mathematical symbolism that is unfamiliar to many people.

I am puzzled by the statement on page 211: "Since the theory of irreversible processes is considered in I, J . . ." Does this refer to sections I and J of this volume? A search of these sections and the index fails to show anything of the "theory," or is this perhaps more mathematical symbolism?

The foregoing criticisms are not to be taken as a general comment on what is generally a fine contribution to the literature on combustion. They are more an expression of my perverse delight in finding minor flaws in so formidable a volume.

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Advances in Electronics and Electron Physics. vol. VII. L. Marton, Ed. Academic Press, New York, 1955. 527 pp. Illus. $11.50.

This volume fully lives up to the very high standards its predecessors have set, and once again the editor has managed to cover a wide variety of topics. The seven contributions to this volume are on the physics of semiconductivity (Burstein and Egli), the theory of the electric properties of Ge and Si (Brooks), characteristic energy losses of electrons (Marton, Leder, and Mendlowitz), sputtering (Wehner), radio astronomy (Wild), analog computers (Vance, Hutter, Lehman, and Wadlin), and electric discharges (Goldstein).

In the first article a thorough survey is given of the experimental data now available on all kinds of semiconductors. The accent is on empiricism and on comparing the various materials. The second article deals with semiconductor theory, especially as applied to Ge and Si. Special attention is paid to scattering mechanisms and optical properties and to recent information about energy band structure. I was rather sorry not to find in this otherwise excellent survey any mention of the recent work on the many-electron model or the polaron model of semiconductors and also hardly any mention of the vast amount of Russian literature—which, unfortunately, is, of course, very difficult to obtain. However, it seems to me that the present state of detailed experimental knowledge makes it necessary to investigate and probably drastically change the basic ideas of semiconductor (and metal) theory rather than change only in detail the 1-electron picture which was adequate, when it was first proposed by Sommerfeld, to a large extent because of the paucity of experimental data.

The third article presents us with a welcome survey of the vast amount of data assembled in the last few years on characteristic energy losses of electrons in solids. It also shows us how far the theoretical interpretation still leaves a lot to be desired. Indeed, one of the greatest virtues of this series of volumes is to my mind their stimulating value to both experimenters and theorists.

The article on sputtering also presents us with a beautiful array of experimental data and with a conclusion that no theory presented up to now has been able to explain the facts. In the article on radio astronomy the experimental point of view is to my mind pushed too far. A few more explanations of the why and wherefore would have been welcome. For instance, the reader might have been told *how* the hydrogen density distribution in our galaxy is determined from the 21-cm line profile.

Analog computers, their construction, components, and use in flight simulation, physics, mathematics, biology, industrial processes, and business and economics are discussed in the next contribution, while a survey of recent developments in the investigation of electric discharges concludes this volume. This last article limits itself to a discussion of the experimental methods that leave the discharge virtually undisturbed and, within its limitation, gives a comprehensive picture. Here also, the way is pointed to further experimental and theoretical research.

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Structure Reports for 1942–1944. vol. 9. A. J. C. Wilson, General Ed. N. C. Baenziger, Ed. for metals; J. M. Bijvoet, Ed. for inorganic compounds; J. M. Robertson, Ed. for organic compounds. Published for the International Union of Crystallography. Oosthoek's Uitgevers MIJ, Utrecht, Netherlands, 1955. 448 pp. Fl. 65.

This volume reduces the gap between *Structurbericht,* 1913 to 1939, and the *Structure Reports* already published, which cover the period 1945 to 1950 in volumes 10 to 13. As in the previous volumes, the reports are distributed in three sections, metals, inorganic compounds, and organic compounds, and an attempt is made to include all the essential structural information relating to solids,