Lines at the Airport

Applied Queueing Theory. ALEC M. LEE. Macmillan, London; St. Martin's Press, New York, 1966. 256 pp., illus. $8.50.

This book is a welcome exception in several respects. In the first place it is *not* another exposition of that pleasant mathematical game called theory of queues, in which idealized waiting lines and servers can be combined to display the nuances of stochastic theory and the intricacies of the Laplace transform. This book discusses actual queuing situations, in which actual people, with all their idiosyncrasies, wait in line to buy tickets, or in which actual buses get loaded at a busy terminal. Not that the mathematics is useless; in fact Lee gives an adequate though condensed review of its fundamentals in his first few chapters and later shows how a great deal of it was used in his case histories of applications.

For this was written by a pro in the field of operations research, by one who is keenly aware of the discrepancies between the mathematical model of an operation and the operation itself, who knows the value of the model as well as its limitations. Lee is not writing for other pros, who know these matters as well as he does. If he were he would have confined his philosophical excursions to a few semicryptic comments and concentrated on describing models and techniques he has found useful, as is the case with most books on operations research since its beginning. This book is addressed to the layman and to the beginner in the field, who is all too likely to assume that beautiful mathematics and the development of ever more complex models are the major tasks of the operations research professional worker. Lee has managed to declassify a series of case histories of actual applications of queuing theory, with enough of the realistic details retained to demonstrate the true nature of the problems faced and solved by the professional.

In the second place this is not so much a treatise on queuing theory as it is a fascinating though fragmentary description, as far as commercial security will allow, of some aspects of the operation called commercial air transport. Only occasionally are we allowed to glimpse the workings of the managerial revolution; the more successful applications of operations research are too valuable to give away to competitors, whether they be other companies or other nations. The air transport industry is not unique, but it is one of the more advanced in its use of "management science." Nearly every airline has a small operations research team, whose members may be glimpsed here and there all over the world, looking into the workings of the system. These professionals have their regular, international conferences; their discussions are not open to outsiders. Military operations research is not the only field which operates behind a security curtain.

Behind this curtain the airline pros have learned a lot about the workings of their industry. They have been at it long enough to be realistic about their model building, to have learned from their failures, and to have built on their successes. They are fortunate in that operational data are abundantly available (or at least are not jealously refused them) so they can check in detail their predictions with the actual outcome, a privilege many of their colleagues, studying other operations, wonder whether they should wish they had. In any case they have come to know a great deal, in a quantitative sense, about their operation. The communications industry and, perhaps, the petroleum industry may be the only others as well explored.

Consequently, to this reviewer, it is intriguing to have a corner of the curtain lifted and to see some fragments of the airline operation from the inside. The added insight may even be of some assistance next time he has to get across the continent and back in a hurry.

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Balancing Rigor and Practicality

Theoretical Numerical Analysis. BURTON WENDROFF. Academic Press, New York, 1966. 253 pp., $10.95.

Analysis of Numerical Methods. EUGENE ISAACSON and HERBERT BISHOP KELLER. Wiley, New York, 1966. 557 pp., illus. $11.95.

Chebyshev Methods in Numerical Approximation. MARTIN AVERY SNYDER. Prentice-Hall, Englewood Cliffs, N.J., 1966. 126 pp., illus. $7.50.

Computer science programs leading to degrees at various levels are being, and have been, established at a number of universities in this country, and some people are questioning and wondering about the existence of a body of knowledge appropriate for university teaching as against the training of technicians.

Of all the various branches of computer science, numerical analysis is undoubtedly the easiest to defend. Perhaps to gain more prestige, many people are engaged in making numerical analysis appear as a branch of mathematics. The books by Wendroff and by Isaacson and Keller are typical of what results. Both have the distinct flavor of mathematics with its characteristic rigor and elegance, while at the same time both keep some of the practical flavor of the practicing numerical analyst who wants to get answers.

After many years of experimentation the subject matter is beginning to settle down to an agreed-upon core of material which includes such topics as simultaneous equations, matrices, and eigenvalues; zeros of functions; polynomial approximation, interpolation, differentiation, and integration, with a small amount on Fourier approximation; and the numerical solution of ordinary and partial differential equations. Both books cover this material, with Isaacson and Keller's being much the more teachable.

There is a similar agreement on the ideas that need to be taught: the estimation and propagation of roundoff and truncation errors; convergence of various iterative methods; and the stability of the approximate methods for solving ordinary and partial differential equations. Although there is still a strong tendency to pick the mathematically elegant ideas over the merely useful ones, both books keep a reasonable balance in this matter.

Besides the basic texts there are in numerical analysis a growing number of monographs and books on special topics, Snyder's book on Chebyshev approximation being very typical. Such books are usually nontrivial in content and represent knowledge that is useful to the people in the field. Not only does Snyder give the relevant theorems and examples, but he also is willing to say (p. 31), "In the author's experi-

ence, it is the best approach to this situation," a remark that is likely to be appreciated by the many people who find that they are suddenly involved in Chebyshev approximation although they have neither training nor experience in the field.

Chebyshev approximation is an example of a branch of numerical analysis that has flowered in recent years as a result of the availability of high-speed, cheap, and reliable computing. The number of ideas and the number of specific details of importance in practice that are now known (as well as some of the pitfalls) are sufficient to occupy a whole course. The idea of Chebyshev approximation, minimizing the maximum error, not only fits in well with computing but is the basis for the mathematical theory of games and is the dominant idea behind much of the current military and economic planning, so the course is not necessarily one for an isolated technician in computing.

Numerical analysis is a curious balance of two forces, the desire for mathematical rigor so that one knows what should happen to him when he acts on the results of perhaps millions of arithmetic operations done on a high-speed computer, of the details of which he can have only the slightest ideas, and the necessity for practical guidance that what he has done is a sensible, reasonably efficient thing to do and has more than mere theoretical justification. After many years the field is gradually finding a balance between the two forces, although books representing the extremes still appear now and then.

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Organic Chemistry

Carbocyclic Non-Benzenoid Aromatic Compounds. DOUGLAS LLOYD. Elsevier, New York, 1966. 230 pp., illus. $13.

Present efforts in the field of non-benzenoid aromatic chemistry represent one of the best examples of the impact theoretical chemistry has had on organic chemistry. Using the molecular-orbital and valence-bond concepts of structure the organic chemist has been aided in the planning and carrying out of syntheses of many important compounds. With the accumulation of over 100 articles a year in this rapidly expanding field, Lloyd's book is a welcome and highly useful review.

In the first chapter an attempt is made to define the terms "aromatic," "non-benzenoid aromatic," and "pseudoaromatic." Because of poor usage in the past, the meanings of these terms have been somewhat distorted. Lloyd's historical approach to defining them, although it does not solve the problem conclusively, will encourage workers to use them more precisely. The remaining chapters take up specific classes of carbocyclic non-benzenoid aromatics, derivatives of cyclopropene, cyclobutadiene, cyclopentadiene (including ferocene), tropylium salts, tropones and tropolones, and medium to large ring systems. The last chapter is concerned with several other polycyclic systems (for example, azulene), as well as the pseudoaromatics pentalene and heptalene.

The book reads well and covers the synthetic aspects of the subject rather completely, although I found a few minor omissions.

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Statistical Method

Applied Regression Analysis. N. R. DRAPER and H. SMITH. Wiley, New York, 1966. 417 pp., illus. $11.75.

This book is based on a set of class notes for a short course for the American Society for Quality Control, originally prepared by the authors in 1962 and subsequently extended and revised. The bulk of the book is concerned with the computation and interpretation of multiple linear regression, but there is a section on nonlinear estimation which appears to have been added to the original manuscript (it has, for example, a separate bibliography), and one on the application of linear multiple regression to analysis of variance. But the essential feature of the book is the treatment (covering some 240 pages) of linear regression.

This is extremely well done. The authors have combined an easily understandable explanation of practical method with an adequate and sound theoretical background. One feature of interest is that the text assumes that results of calculations will usually become available in the form of computer output. Many examples and exercises thus have an appearance (with a uniform 7 decimal places shown) which is rather strange to one used to reading more conventional texts. Another feature both unusual and welcome in a book of this kind is the systematic use of matrix notation. The meaning of this notation is clearly explained. Indeed, the authors seem to go rather too far in protecting their readers when they decide not to expose them to an actual definition of the value of a determinant—they call it "a quantity which we shall not define here but of which we shall provide some examples" (p. 47). Particularly valuable chapters are those on "The examination of residuals" (chapter 3), "Selecting the 'best' regression equation" (chapter 6), and "Multiple regression and mathematical model building" (chapter 8). This last chapter is so interesting that one could wish it were much longer than ten pages. Chapter 6 discusses an important problem and provides lucid explanations of procedures used in current practice. Where the authors give their opinion on the usefulness of a procedure, the relevant paragraph is clearly labeled OPINION; I found this most helpful in recognizing points at which results of personal experience were stated, as opposed to generally accepted facts.

The final chapter, "An introduction to nonlinear estimation," is rather more complex than the remainder of the book but is also very clearly written. It includes a section on the geometry of linear least squares, which is relevant to the earlier part of the book, and contains some unusually fine pictorial representations of solid geometry. The dependence of the method of steepest descent on choice of scale—in fact *any* direction (apart from signs) can, in general, be obtained by appropriate choice of scale—is, unfortunately, not given as much emphasis as it deserves. Another place where there is some unnecessary confusion is on page 71 where "sequential F-test" is used to describe a sequence of F-tests on a given set of data. It is admitted that "some writers dislike" this, but the reason (that of possible confusion with "*genuine* sequential F-test") is not mentioned. However, blemishes such as this are few, and not serious enough to affect the value of this book as an outstanding means of obtaining operationally effective command of the techniques of regression analysis.

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