rithm. The third article, "The Existence Theory of Optimal Control Systems," by W. W. Schmaedeke gives a fairly elementary exposition of some of the principal existence theorems, in the usual mathematical setting, for linear as well as nonlinear control systems. The fourth paper, by James M. Swiger, entitled "Application of the Theory of Minimum-Normed Operators to Optimum-Control-System Problems," presents a treatment of various typical control problems in the setting of the moment problem of Akhieser and Krein. The fifth paper, "Kalman Filtering Techniques," by H. W. Sorensen discusses the linear estimation theory as developed by Kalman and others, mainly in terms of a time-discrete model. The last paper, by Stanley F. Schmidt, entitled "Application of State-Space Methods to Navigation Problems," uses the navigation problem as an example to demonstrate the usefulness of various simple mathematical concepts and techniques.

Volume 4 also contains six contributions. The first, by David Isaacs, on "Algorithms for Sequential Optimization of Control Systems" reviews various methods for the numerical solution of the optimal control problem and reports on some computational experiments with them. The second paper, "Stability of Stochastic Dynamical Systems," by Harold J. Kushner gives a brief thoroughly mathematical introduction to Lyapunov's second method as it applies to stochastic stability. The third paper, by Richard E. Kopp and H. Gardner Moyer, entitled "Trajectory Optimization Techniques," discusses the computational solution of optimization problems by indirect methods, gradient methods, the second variation and the generalized Newton-Raphson method, and lists some of their relative advantages and disadvantages. The fourth article, "Optimum Control of Multidimensional and Multilevel Systems," by R. Kulikowski, is concerned with the reduction of complex optimization problems to problems of second- and higher-level control by using for first-level control the known results of standard optimum-control theory. The last two papers are both by Donald E. Johansen. In "Optimal Control of Linear Stochastic Systems with Complexity Constraints" he gives a detailed treatment of a linear stochastic system when the estimator is not of the same order as the process being controlled. In "Convergence Properties of the Method of Gradients" he obtains qualitative results using a large amplitude theory for deviations of the control from the optimal solution and quantitative results in the asymptotic region of small perturbation.

Though the level of presentation varies a great deal and requires different degrees of mathematical and engineering sophistication, these collections should nonetheless be of some use to the informed reader interested in particular aspects of control problems.

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96[P, X, Z].—Moshe F. Rubinstein, *Matrix Computer Analysis of Structures*, Prentice-Hall, Inc., Englewood Cliffs, N. J., 1966, xiv + 402 pp., 24 cm. Price $12.95.

This text is intended for use in a one-semester senior course or beginning graduate course. As the title of the book would indicate, the intention of the author is not to develop the classical methods of structural analysis, but rather to emphasize

those techniques which are directly applicable to computers. Thus an introductory chapter is devoted to computers (including a brief description of FORTRAN), and in two succeeding chapters the necessary concepts of linear algebra are developed. The remainder of the book emphasizes matrix methods along with various techniques of solution and can best be described by simply listing the chapter headings: Computers—Fundamental Concepts, Structures—Fundamental Concepts, Characteristics of Structures—Stiffness and Flexibility, Determinants and Matrices, Solution of Linear Equations, Energy Concepts in Structures, Transformation of Information in Structures, The Flexibility Method, The Stiffness Method, Analysis by Substructures and by Recursion, Analysis by Iteration, Analysis of Plates and Shells—Introduction. Each chapter contains a selection of problems with answers given at the back of the text. The book is clearly written, and can be recommended for use in a computer-oriented course in structural analysis.

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97[Q].—MILTON P. JARNAGIN, JR., *Expansions in Elliptic Motion*, constituting Volume XVIII of *Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac*, U. S. Government Printing Office, Washington, D. C., 1965, xxxvi + 659 pp., 29 cm. Price $4.50 (paperbound).

This volume is, in effect, a repetition and extension of Cayley's classical tables [1], giving the literal expansions as harmonic series, in the mean anomaly, of such functions as $(r/a)^n \exp(i\,m\,f)$, $\log(r/a)$, and the equation of the center. These expansions are carried to the 20th power of the eccentricity, and all the numerical coefficients are rational fractions.

The Introduction is a model both of clarity of exposition and of probity in the care with which this large computing project was planned and programmed. There is no evidence of any hammer-and-tongs approach, even though the most powerful electronic computer of its day, the NORC, was available for the work, performed at irregular intervals in 1961 and 1962.

For the record, the Introduction should have included an explanation of the printing process. Both for reliability and economy, the computer output was recorded on microfilm by means of the NORC cathode ray tube. Judicious programming provided a compact, self-explanatory format. Owing to the extremely high reliability of the NORC, it may be assumed that probably not a single digit in the 659 pages of tables is in error. Unfortunately (and as a sad commentary on these times) the review copy has 16 pages of one whole signature completely illegible, because of careless printing-press workmanship.

The personnel of the Naval Weapons Laboratory and the Nautical Almanac Office are to be commended for their excellent collaboration in producing and publishing this volume. As a desk-type reference for workers in celestial mechanics, it may be expected to serve all needs during the second century of existence of Cayley's Tables.

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