More importantly there are no problem sets, which is probably a fatal omission insofar as most American university teaching is concerned.

The text of White and Tauber is aimed at a slightly lower level. As mentioned above, Part I, almost a third of the text, is devoted to mathematical topics in linear algebra, extremal prolems, calculus of variations, and ordinary differential equations. Part II introduces Hamiltonian mechanics and electromagnetic theory at a fairly elementary level. It is not until Part III that we encounter applications to specific systems types. Due to the large amount of space devoted to background material, the treatment, though commendably broad, is regretably brief.

Little attention is devoted to the unification of lumped system analysis possible via linear graph techniques. Instead, emphasis is placed on variational techniques, which are most efficient for low order, linear, conservative systems. There are short chapters on satellite orbits, rotating machines, vibrations and feedback systems, as well as a discussion of applications of system theory to fields outside engineering; i.e., biology, economics, etc. A small collection of problems is included at the end.

Overall, the book by MacFarlane is at a bit higher level, suitable perhaps for a first year graduate introductory course. The high price and lack of problem sets, however detract from its attractiveness as a textbook.

CHEMICAL PROCESS CONTROL, by L. A. Gould, Addison-Wesley, 1969, pp. 370.

REVIEWED BY LEON LAPIDUS[4]

In reading this book on chemical process control, one is immediately struck by the fact that it was written by an electrical engineer rather than a chemical engineer or a chemist. As such it brings to bear areas of control which the chemical engineer would ordinarily not encounter and at the same time discusses certain areas of perhaps minor importance. In other words, there is a blend of fairly detailed and high-level analysis coupled with some simple material on flow, pressure, and liquid level controllers. All in all however, the presentation is an excellent one which most chemical engineers could profit materially from reading in detail.

The main chapters of the book include first a chapter on models for flow processes and another on regulation theory. These are superbly done including an analysis of percolation processes, sensitivity techniques, and interacting control. The next chapter on flow, pressure, and liquid level control is rather straightforward and contains material equivalent to that in many other texts. The next two chapters deal with heat transfer and mass transfer processes in all types of systems such as heat-exchangers, distillation columns, packed bed absorbers, and even involving Taylor-diffusion transfer. These chapters are both well done and contain a wealth of interesting material.

The next chapter is a unique one since it deals with modal analysis of systems, i.e., how to rationally decrease the order of a system. The analysis here is absolutely top level and includes such topics as spectral operators, infinite dimensional spaces, and other advanced concepts which normally would not be in a book like this.

Finally, the book ends with a chapter on chemical reactions including optimal control. This chapter is probably not too important since the discussion on chemical reactors is very elementary and the optimal control section is too short (only eleven pages). Nevertheless, it does bring certain concepts to the reader's attention.

The book is well written, has excellent examples sprinkled throughout the discussion, and well-conceived problems at the end of each chapter. The references leave a little to be desired since many of them are rather old except for references to specific M.I.T. work. Even with these slight defects, the book is a very welcome one and presents a wealth of information. It is highly recommended to engineers who wish to see chemical process control from a perspective not usually given.

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DISCRETE-TIME AND COMPUTER CONTROL SYSTEMS, by J. A. Cadzow and H. R. Martens, Prentice Hall, 1970, 473 pp.

REVIEWED BY C. H. BARKELEW[5]

This book has grown out of a course given at the State University of New York, where both authors are on the faculty of Electrical Engineering. It is intended for senior students in Electrical and Mechanical Engineering. It contains a large number of illustrative examples and problems, and each of its chapters concludes with a summary and list of pertinent reference material. Appendices to certain of the chapters contain listings of Fortran Source programs, and mathematical proofs where appropriate.

After an introductory chapter, in which the authors emphasize that their attention is to be directed toward linear discrete-time systems, they proceed in Chapter Two to a discussion of the various ways of representing such systems in the time domain. Chapter Three is concerned with analysis of linear discrete systems, and includes such topics as sampled data and data-hold techniques. Chapter Four is an exposition of z-transform theory, and is a basis of much of the treatment in later chapters. Chapter Five introduces the student to the concept of state variables and to their use in representing physical systems. Chapters Six and Seven bring the preceding expository material together into the principles of analysis and design of discrete systems. Chapters Eight and Nine are devoted to the use of computers in control systems. Here the main emphasis is on digital methods, although the use of analog and hybrid computers as simulation tools is touched briefly.

The book was written specifically as an undergraduate text, and as such can be of great use to teachers in preparing their own courses of instruction. Since it has evolved from experiences in organizing and presenting material for students, rather than from experience in real applications, practicing engineers will find it useful for self-teaching, but not as a comprehensive source of reference material.

Its principal virtue is in the large number of problems and examples which have been used to illustrate and develop the subject matter.

MATHEMATICAL METHODS OF OPTIMAL CONTROL, by V. G. Boltyanskii (translated by K. N. Trirogoff; edited by Ivin Tarnove) Holt, Rinehard and Winston, Inc., N. Y., 1971, 272 pp.

REVIEWED BY GEORGE LEITMANN[6]

This volume is a translation of Boltyanskii's book (of the same title) which was published in the Soviet Union in 1966. It contains much of the subject matter of the classical volume

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on the Maximum Principle (Pontryangin, Boltyanskii, Gamkrelidze, and Mishchenko, *The Mathematical Theory of Optimal Process*, Interscience Publishers, N. Y., 1962). However the mathematical presentation is "pitched" somewhat lower here and hence is considerably more accessible than that of the original treatment. Of course, this (welcome) decrease in the required level of sophistication entails some weakening in the results. On the other hand, subject matter not considered in the "parent" volume is included here; for instance, sufficiency theorems are given here but not in the earlier volume.

Chapter 1 contains an introductory section on control processes governed by ordinary differential equations, the definition of time-optimality (minimum time transfer between given states), sufficiency via dynamic programming, a derivation of necessary conditions via dynamic programming together with a critique of this approach, and a discussion of feedback control (synthesis).

Chapter 2 begins with a review of geometric notions to be employed and then presents a derivation of the Maximum Principle for time-optimal control in the class of piecewise continuous controls.

Chapter 3 introduces the subject of convex polyhedra which is used in the subsequent treatment of time-optimal linear systems. Under suitable restrictions ("general position" condition), the Maximum Principle is shown to be necessary and sufficient for time-optimality. The chapter contains also various special results; among these are a bang-bang theorem, a theorem on the number of switches, a uniqueness theorem, and an existence theorem (for piecewise continuous controls!). The chapter concludes with a discussion of computational methods including analog simulation and the methods of Neustadt and Eaton.

Chapter 4 is primarily devoted to sufficiency conditions for time-optimality; the main result is the theorem which appeared first in English in *Journal of SIAM on Control,* Vol. 4, 1966, pp. 326–361. Some examples of time-optimal control synthesis for second order systems are presented.

Chapter 5 contains various generalizations. In particular, the Maximum Principle, heretofore restricted to time-optimality, is extended to integral cost functionals with positive integrands. Also treated are variable endpoint problems, non-autonomous systems, systems with parameters, and fixed time and isoperimetric problems.

In conclusion, with the proviso in mind that the treatment of optimization of dynamical systems is solely from the Maximum Principle point of view, this book is highly recommended.

NUMERICAL CONTROL, by Glen Ertell, Wiley-Interscience, a division of John Wiley & Sons, Inc., New York, 1969, 149 pp. (plus index 3).

REVIEWED BY H. THAL-LARSEN[7]

NUMERICAL control, as treated here, is defined as that part of an electromechanical system that utilizes digital logic circuits causing the system to respond to instructions received from digitally coded tapes. This small book does not include the host of other topics associated with numerical control (NC), such as programming, tooling, economics, and training. By concentrating on the techniques that are common to all numerical controls with emphasis on logic functions the author has succeeded in writing a book which should prove to be useful to engineers and technicians who must apply and maintain NC systems. In this respect the book is unique; other volumes on NC do not seem to include detailed information on the logic circuits which are used.

Mr. Ertell is an electrical engineer, educated at Carnegie Institute of Technology. In postgraduate work he concentrated on the study of servomechanisms, digital circuits, and digital computer design. He has grown up with NC, having been employed in various responsible engineering postions in that field, including Senior Project Engineer in the Numerical Control Section of the General Electric Specialty Control Department. At General Electric he founded and was an instructor in the Numerical Control School associated with his department. Experience in both the design of NC systems and in teaching the subject has enabled the author to write a well-organized, clear, concise, easy to read, and interesting little volume.

The table of contents lists the following chapter headings: 1. Introduction to Numerical Control; 2. Binary Numbers and Arithmetic; 3. Basic Digital Circuits; 4. Binary Counters; 5. The Selection and Collection Numerical Control; 6. Numerical Positioning Using a Stepping Motor; 7. The Power Servo; 8. Numerical Positioning Using a Servo; 9. The Single-Axis Continuous-Positioning Numerical Control; 10. The Two Axes Continuous-Positioning Numerical Control; 11. Punched Tape Readers; 12. The Technique of Troubleshooting.

One may very well ask whether or not he should read this volume on NC now that the digital computer is becoming more and more involved in the control of machine tools. In answer to the question, it would seem reasonable to anticipate development of both NC, with its more conventional hardwire logic, and direct numerical control (DNC), with its software, for some time to come. Each system has advantages and disadvantages, depending upon the application, and the particular situation. Therefore it is probably advisable to study both systems. And, for the hardwire logic of NC, this volume is highly recommended.

DISCRETE-DATA CONTROL SYSTEMS, by Benjamin C. Kuo, Prentice-Hall, Inc., Englewood Cliffs, N. J., 1970, 399 pp.

REVIEWED BY L. M. ZOSS[8]

THE aim of the book as noted by the author is to provide a comprehensive coverage of the analysis and design of discrete-data control systems, with emphasis on the modern approach and the design of optimal control systems.

As noted in the Preface, "The topics included in the text are those which the author considers suitable for a one-semester course in discrete-data control systems. Much of the material has been class tested during a period of more than ten years. The book is also prepared with the needs of modern engineers in mind; it should therefore prove useful as a reference. The text has been designed so that it may be studied with a minimum amount of guidance." In making these statements the author assumes that the reader has a knowledge of the basic theory of feedback control systems.

The first five chapters (or part one of the text) are devoted to analysis. These chapters cover discussions on sampling and data-reconstruction processes, the Z-transform method, the state variable technique, and stability. With the exception of the state variable technique which is emphasized, much of the material is a repeat of that presented in the author's previous text *Analysis and Synthesis of Sampled-Data Control Systems.*

Chapters 6 through 9 (or part two) are devoted to design of discrete-data systems. These chapters cover time-optimal design, optimal-design with respect to the minimization of a performance index, and statistical analysis and design. Here again some of the material, especially in the area of statistical analysis, is repeated from the author's earlier text. Chapter 10 (or

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The proposed use of the optimal control theory methods for solving scheduling problems makes it possible to improve the quality of planning results (including increasing the efficiency of obtaining a plan, reducing the cost of resources when implementing it). Information on practical implementation of the developed models and algorithms is given.Â Mathematical models of drilling systems with discontinuous friction torque characteristics are considered. Here, opposite to classical Coulomb symmetric friction law, the friction torque characteristic is asymmetrical. Problem of sudden load chande is studied. Mathematics Applied Mathematics Control and Optimization. Publisher. John Wiley & Sons Inc.Â Optimal Control Applications & Methods provides a forum for papers on the full range of optimal and optimization based control theory and related control design methods. The aim is to encourage new developments in control theory and design methodologies that will lead to real advances in control applications. Papers are also encouraged on the development, comparison and testing of computational algorithms for solving optimal control and optimization problems. The scope also includes papers on optimal estimation and filtering methods which have control related applications. Papers on optimal, control theory, reviewed in Referativnyi Zhurnal â€œMatematikaâ€ during 1971â€“1975, are surveyed.Â L. D. Akulenko and F. L. Chernous'ko, â€œAveraging method in optimal control problems,â€ Zh. Vychisl. Mat. Mat. Fiz.,15, No. 4, 896â€“882 (1975).Google Scholar. 2. A. G. Aleksandrov, â€œProperties of analytically designed linear systems,â€ Avtom.