

conceived problems are included. Subject matter is chosen well and discussed; a carefully selected bibliography has been included for each section.

This book represents the thoughts of a teacher and scholar who articulates both the substance of chemical engineering and its significance to the solution of biomedical problems. Individuals with a thorough knowledge of classical transport phenomena can easily expand that knowledge in a new and exciting direction. Others must be prepared to read carefully and to expend a certain amount of scratch paper to follow some sections. Those who take the effort will find it a rewarding experience.

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**Process Modeling, Estimation, and Identification**, John H. Seinfeld and Leon Lapidus, Vol. 3 of *Mathematical Methods in Chemical Engineering*, Prentice-Hall, Englewood Cliffs, N.J. (1974). \$19.95. 545 pages.

The mathematical method employs models that represent engineering processes; occasionally, it is used to actually generate the model. By comparison of model prediction with observed behavior, one attempts to estimate the numerical values of the model parameters and to, incidentally, assess the quality of the proposed model. Investigations of this type are common, indeed necessary, in research and development, with particular emphasis on model assessment and systematic parameter evaluation, and in the engineering practice, when the parameters of an accepted model need be finely tuned for optimal representation in some application. Consequently, parameter estimation techniques are important for both the (academic or industrial) researcher and the practicing engineer in the plant.

Today's development of these techniques is rapid and diversified; hence, a textbook which specializes in this branch of engineering mathematics, allowing for the specific circumstances and conditions of chemical engineering, is badly needed. The authors are eminently qualified for the task on account of their productive involvement in this area.

The book is well balanced with respect to informative contents, describing and explaining the several techniques and the logical interrelation of the presented material. Wherever the

size of the book limits the extent of the discussion of offered material or precludes the presentation of additional topics, sources of further information are clearly stated. Examples taken primarily from chemical engineering situations promote the realistic understanding of abstract concepts. Extensive sets of carefully assembled problems are appended to Chapters 2 to 10; solutions are not included.

The authors explain the objectives of the book in the very brief Chapter 1; they argue in favor of a separate course in process modeling within the chemical engineering curriculum. In fact, the mathematical background of a senior engineering student satisfies the prerequisites of the book; some basic knowledge of matrix algebra and of matrix analysis is presumed throughout the book.

Mathematical formulations (for continuous and for discrete variables) of deterministic models for processes, with attention to state variable representation, are introduced in Chapter 2.

Chapters 3, 4, and 5 offer auxiliary material in the form suitable for subsequent use. The Laplace-transformation is introduced in Chapter 3, via the Fourier-transformation, and extended (for discrete data sets) into the Z-transformation; properties and theorems are presented, with special emphasis on the transfer function concept, and then employed in the solution of several challenging problems. Chapter 4 provides a compact introduction to the fundamentals of probability theory, covering that portion of an undergraduate course which is required in the subsequent chapters. In particular, it serves as basis for Chapter 5, Stochastic Mathematical Models, a topic which is not yet generally included in the undergraduate engineering programs in spite of its importance. The chapter includes the stochastic process, its several specialized forms (Markov, Poisson, Wiener), correlation, autocorrelation, and the Fokker-Planck equations, thus supplementing the deterministic models of Chapter 2.

Chapter 5 guides one naturally into Chapter 6, Residence Time Distribution Theory. The development of this theory, which is prerequisite for many other theories of chemical engineering, employs both the deterministic and the stochastic model; thus, it provides an application of the latter and an opportunity of comparison. The estimation of model parameters is systematically developed in Chapter 7; in particular, the discussion includes models expressed by algebraic, differential, or partial differential equations, and methods of least squares, maximum likelihood, Bayesian estimation, moments, and transfer functions with determinis-

tic or stochastic inputs. The development of the principles of estimation is supplemented by algorithms for actual evaluation and assisted by several examples. Methods for the estimation of the reliability of the parameter evaluation together with logical consequences for the design of experiments intended for the estimation of some specific parameter are presented in Chapter 8, Design of Experiments for Parameter Estimation. Chapters 9 and 10, Process Identification for Linear and Nonlinear Systems, respectively, provide a brief introduction into the task of process identification. In the former, it is shown how a state variable representation of minimum dimension can be constructed for a linear process, when the response to impulse input (or control) variables is known. In the last Chapter 10, the difficulties and possible techniques of identification (Wiener theory, finite Volterra series) of nonlinear systems are explained.

Indeed, the authors have not only suggested the introduction of a course in process modeling, they have also given us the textbook upon which such a course can be built. Of course, one must remember the already crowded curriculum. At the graduate level, Chapters 2 and 5 to 8 (possibly 9 or 10) would form the basis of an interesting and inspiring one-semester course; possibly, through reorientation of an existing graduate course in applied mathematics. Similar thoughts apply to modifications of the undergraduate program. Of great help would be the prior introduction of the stochastic process; possibly, though reorganization of the usual undergraduate course in probability and statistics.

Equally important is the help which this book offers the practicing engineer; familiarized with concepts and with terminology of process modeling, he can follow and appreciate the extensive literature, practically benefit from theoretical and experimental results, and stimulate the development with suggestions and requests.

This is a professional book; engineering as well as mathematical contents are written for the engineer, not for the abstract mathematician; the latter might occasionally disagree with the presentation. For instance, the Dirac (pseudo-) function of the impulse is not presented in the modern, mathematically consistent theory of distributions (Schwartz, 1950). A number of misprints have escaped detection in the proofreading process; fortunately, most of these are easily discovered and corrected.

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