# BOOK REVIEWS

## Linear Operator Methods in Chemical Engineering

By D. Ramkrishna and N. Amundson, Prentice-Hall, Englewood Cliffs, NJ, 471 pp., 1985, $51.95

When one considers the relevance of functional analysis in chemical engineering curriculum for graduate students, three particular reasons stand out: modern development in numerical analysis, parameter estimation and sensitivity analysis, and unification of seemingly diverse fragments in the theory of linear differential operators. This new text provides an introduction to functional analysis with applications in the theory of linear differential operators at a level suitable for students who have mastered an introductory course in engineering mathematics. Students familiar with the first half of this book will also have an easier time with entry level texts on modern numerical methods.

This book was used as a required text in a one-semester course at the University of Wisconsin and this review includes remarks that are drawn from that experience.

The first two chapters (0, 1) of LOMChE condense the elements of real analysis into 23 pages. In the undergraduate mathematics curriculum, a course in real analysis is a prerequisite for functional analysis. Engineering students are not familiar with this material and this portion of the course required careful discussion, e.g., the motivation for various definitions.

Linear algebra as described in Chapter 2 is likely to be more abstract than material encountered in previous courses on matrix manipulations, but the approach sets the tone for later materials.

In Chapter 3, "Metric Spaces," concepts such as the metric, convergence of sequences, Cauchy sequences, continuity of functions, interior points, open and closed sets, limit points, closure of a set, compact sets, complete metric spaces, dense sets, etc., and associated theorems are introduced and derived. Many new concepts are introduced here so this portion of the course presents the greatest challenge to both instructor and student.

Chapter 4 introduces Lebesque integration and measure theory which achieves two results: it introduces an important example of completion of a metric space (space of Lebesque integrable frunctions vs. Riemann integrable functions); it also prepares important examples of Banach and Hilbert spaces that appear in later chapters.

Chapters 5 and 6 cover normed linear spaces and inner product spaces. Chapter 5 highlights concepts and theorems that require only the existence of a norm (instead of the full machinery of the inner product). The topology induced by the norm, the natural norm induced by the inner product, norm of an operator, compact operators, Banach spaces, Hilbert spaces, the Riesz Representation Theorem and adjoint of an operator are presented in these two chapters.

Chapters 0 through 6 may be viewed as preparation for applications found in later chapters. As mentioned earlier, the ideas presented in these chapters have other applications. Chapter 7 features a rigorous derivation of the spectral theorem for both finite- and infinite-dimensional Hilbert spaces. The derivation is essentially complete. Chapter 8 presents applications in finite-dimensional spaces such as multicomponent distillation problems.

In Chapters 9 and 10 (ODEs and PDEs respectively), the conversion of self-adjoint differential operators into integral equations via Green's functions is discussed in the context of the construction of compact inverses. Here we see the fruits of a course based on LOMChE. Instead of the usual arguments on the advantage of integral equations over differential equations, here, the advantage is evident.

The book ends with an introduction to nonself-adjoint operators and biorthogonal expansions (Chapter 11). It is interesting to note that during the same semester, the biorthogonal expansion was applied successfully by one of the students to resolve a research problem.

The authors have included enough material for a two-semester course including many thought-provoking exercises. Our one-semester course covered all of Chapters 1, 2, 3, 5, 6, 7 with appropriate references to material in Chapters 0 and 4 and one topic from Chapters 9, 10 and 11 each. The syllabus was intentionally in favor of foundation material over applications. A slower pace can be set by reducing the emphasis on Chapters 1, 2 and 3. Other combinations are mentioned in the preface.

In summary, this book is an excellent introduction to functional analysis for applications in linear operator theory. The aims as embodied in the title have been achieved without major omissions. Some of the typographical errors may hamper students who are reading this book on their own, but these minor flaws most likely will be corrected before the next printing. Numerous transport and reaction engineering applications make this book especially suitable for self-study by graduate students.

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## Process Analyzer Technology

By K. J. Clevett, John Wiley and Sons, Inc., 1986, 952 pp., $105.00

This book addresses a wide range of process analyzers, including chromatog-