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Applied Mathematics: Methods and Matlab

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Applied mathematics is a field concerned with applying knowledge from pure mathematics to other domains. This involves building models and analyzing solutions of those models. With the ubiquity of computers, many models—too complex for analytical solution—can be studied numerically. The details of those computational aspects, such as data structures, algorithms, and numerical approximation, are also mathematical in nature. In common practice, much of what the physical scientist or engineer (the target audience of this book) is tasked with reduces to translating physical models into differential equations and studying the solutions of those equations.

Roughly 50 percent of the book covers the solution of ordinary and partial differential equations while the remainder includes relevant introductory material on matrix and vector algebra and calculus, eigenvalue problems, and systems of equations. Advanced undergraduate or graduate students in engineering or physical sciences will be comfortable with the level of exposition in this book. Those further along in their careers will also appreciate the book as a reference work or starting point. The appendices, available in PDF form from the publisher's website, nearly double the length of the book, providing significantly more depth for those interested. The selection of topics is quite pragmatic and reflects the author's chemical engineering background.

The book is divided into four parts:

1. matrix theory,
2. vectors and tensors,
3. ordinary differential equations, and
4. partial differential equations.

Thomas B. Co, *Methods of Applied Mathematics for Engineers and Scientists*, Cambridge Univ. Press, 2013, ISBN: 978-1-107-00412-2, 559 pp.

Each part contains several (2–5) chapters each containing examples and exercises. There's an appendix for every chapter and about 50 Matlab codes available for download.

The first part covers introductory definitions, solutions to systems of equations, matrix decompositions, and matrix operators. These are rather broad topics and the focus is on setting up for the latter discussion of differential equations. Those interested in numerical linear algebra will benefit from corresponding appendices for these chapters. The second part continues the theme by introducing vector and tensor algebra, coordinate transforms, and vector calculus. Of note in this part is the discussion of translating physical models into differential equations. The remaining two parts of the book are dedicated to the analytical and numerical solution of ordinary and partial differential equations. In the four chapters on ordinary differential equations, the author covers analytic approaches, numerical integrations, analysis of qualitative solution behaviors, and series solutions (such as Legendre and Bessel equations). The treatment of partial differential equations covers linear and first-order nonlinear cases. There are also chapters relating to the important finite difference and finite element methods. The treatment of partial differential equations is necessarily incomplete given the scale of the field. For example, there are entire textbooks covering the finite element method in different contexts. However, each chapter will serve as an accessible starting point, and with well-chosen topics, the book will likely be sufficient in many cases. Exercises are found at the end of chapters and a solution manual is available to instructors on the publisher's website. Many of the exercises reflect Co's chemical engineering background; otherwise, the exercises cover a broad range of topics.

Co succeeds in providing a book that tightly integrates theoretical background and analytical methods with practical numerical techniques. Some highlights of the work are the included example codes, the extensive appendices, and included examples and exercises. Specifically, the application section of chapter 5, which covers the translation of physical models to tensor calculus, was a highlight.

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There are, however, a few caveats and nit-picks. The numerous included codes are written in Matlab, and it should be noted that Matlab is not freely available. Many academics will have access to a license or, at least, discounted prices. Whether to use a program that is not open source, however, is a personal philosophical decision left to the potential reader. In terms of substance, the codes are a great resource, although I would have appreciated more comments and a little more consistency in coding style.

The appendices are quite extensive and really add to the book's value. I found the PDF format to be slightly less useful than a physical text, but that will vary based on the use case and workflow of the reader. One thing I would have appreciated would have been more references for those seeking more depth on specific topics.

In summary, this textbook is a positive addition to available applied mathematics literature; it succeeds in combining analytic and numerical methods on a range of topics, particularly differential equations. Apart from a few minor shortcomings, this book will help any student or scientist—especially those using Matlab—understand and use mathematics in their work. ■

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