sented here will, hopefully, give the instructor courage to teach such a course without hesitation.

## ACKNOWLEDGMENT

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## ChE book review

### *Mathematical Methods in Chemical Engineering*

*by A. Varma and M. Morbidelli*
Oxford University Press, New York, NY; 690 pgs; $80 (1997)

*Reviewed by*
**E. James Davis**
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This text follows the Minnesota tradition of applied mathematics in chemical engineering established by Professors Amundson and Aris in that the treatment of the numerous topics is rigorous and vigorous. There is an attempt to complement the mathematical fundamentals with examples arising in chemical engineering, but the balance between theory and application is not uniform throughout the book. The authors naturally lean toward examples from their own research and experience.

The nine chapters cover a wide range of subject matter starting with matrix theory and proceeding to a particularly long chapter dealing with first-order linear ordinary differential equations and stability theory. With respect to Chapter 1, the authors acknowledge their debt to Professor Amundson; that chapter summarizes Amundson's book *Mathematical Methods in Chemical Engineering: Matrices and Their Application.* The first two chapters account for almost one-third of the 690-page book, but Chapter 2 addresses subjects such as Liapunov's direct method and the Hopf bifurcation theorem not covered in typical texts on advanced engineering mathematics. The 135 pages of Chapter 2 include interesting applications such as the analysis of the Belousov-Zhabotinskii oscillatory reaction.

Chapters 3 and 4 are more conventional in their coverage of linear ordinary differential equations and special functions, respectively. A clear presentation of the Green's function for solving nonhomogeneous equations is a plus. The applications included in these chapters are rather lean, and the presentation of orthogonal polynomials such as the Chebyshev and Laguerre polynomials and other special functions is left to problems at the end of Chapter 4 without relevant applications.

The classification of partial differential equations in Chapter 5

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## GENERAL COMMENTS

We found that many students have no idea how to perform a literature review. Often, an internet search was conducted using a web-crawler (Alta Vista or a similar program). Approximately one-half of the literature reviews consisted of a rambling essay about motivation or previous work, with no specific citations of the literature. We asked a number of groups to revise their literature review.

Clearly, our case studies in multivariable control require a lot of effort and coordination of all members of the instructional team. It is important to have a robust simulation set-up for the students to perform their initial identification tests. It is also important to provide rapid feedback. Groups generally turned in their memo reports on Friday, and we usually evaluated them and returned them to the students on Monday.

Comments from the undergraduate students have generally been favorable. The case studies give them the opportunity to "tie it all together" and to understand each component of a control-system design project. It should also be noted that the role of the case-study advisors shifts during the projects, ranging at various times from boss to intelligent co-worker to all-knowing judge and inquisitor.

## FUTURE TEACHING EFFORTS

Currently, the control course has been taught in a fairly traditional lecture/recitation/computer-lab format, with three lectures and one recitation per week. The recitation typically covers the assignment for that week or reviews a recent exam. Students are also expected to participate in one computer laboratory session per week.

There is a move in the Rensselaer curriculum toward "studio" or "workshop" learning, where students meet twice a week for two-hour sessions with a faculty member and one or two teaching assistants. The idea is for the students to learn interactively by solving problems rather than by passively listening to lectures. Rensselaer is currently renovating or constructing a large number of classrooms to fit the studio format, with student workstations (not just computers) where students can interact and solve problems in groups. The instructor or teaching assistant can give "mini-lectures" as groups encounter common stumbling blocks or can provide more background material as needed.

Since the dynamics and control sequence is taught during the junior year, it offers an excellent opportunity to consider process control implications in the process-design course. We plan to do this as process-flowsheeting packages begin to have dynamic extensions that are relatively easy to use.

## SUMMARY

We have presented an approach to using case-study projects in a process control course. The projects are more open-ended than typical undergraduate assignments, provide more experience working in a group environment, and further develop written and oral presentation skills. In addition to the learning experience for the undergraduates, we have found that the teaching assistants, the graduate students, and the instructor also learn from the approach.

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# BOOK REVIEW: *Mathematical Methods*

*Continued from page 189*

takes a fairly classical approach, and the authors dig into first-order partial differential equations in Chapter 6 with relish. They offer a particularly thorough treatment of the subject replete with examples of waves, shocks, and weak solutions. This is obviously a favorite topic of the authors, and many chemical engineers dealing with packed bed or chromatographic separations will find meaty bones to chew on in Chapter 6.

Fourier and Hankel transforms are covered in Chapter 7, but the applications to the vibrating circular membrane and semi-infinite strips and cylinders are not particularly stimulating for the chemical engineer. The applications of Laplace transforms in Chapter 8 are probably of greater relevance to chemical engineers.

Although the references at the end of each chapter are not extensive, they are well thought out and direct the interested reader to more comprehensive treatments of the subjects. The variety of mathematical tools useful to chemical engineers is reasonably well covered, and the authors point out that they felt it necessary to exclude complex variables, statistics, and numerical methods. It would have been reasonable to include a short summary of similarity analysis because similarity solutions are so often encountered in fluid mechanics and heat and mass transport processes. An instructor may wish to supplement the book with examples of similarity analysis.

Some of the chapters are beyond the abilities of many undergraduates, but chemical engineering graduate students would profit greatly by working through the entire nine chapters. I plan to use this text in my graduate course in mathematical methods applied to chemical engineering, replacing Hildebrand's widely used book *Advanced Calculus for Applications,* because it is necessary to supplement Hildebrand's book with chemical engineering applications. Varma and Morbidelli do this well and at a cost that is reasonable.

One finds that the book has been carefully proofread, for it is difficult to find typographical errors. The figures are simple and uncluttered, and they are entirely adequate to illustrate the relevant mathematics. There is a good set of problems at the end of each chapter, and many chemical engineering applications are incorporated in these problems.

The rigor and sophistication of this book go well beyond the few competing texts that claim to be advanced mathematics for chemical engineers, and I can add my humble imprimatur to those of Professors Amundson and Aris who encouraged the authors to write this book. ❐