favorable. When asked their opinion of the course afterwards, students responded that they "enjoyed the project" and that it was "fun"—phrases rarely used to describe a typical homework set.

We did receive a few less positive responses at the beginning of the project. While some students liked the flexible nature of the project, a few students worried about what was meant by "the project's success being up to them." Several students were initially turned-off by the idea of an open-ended literature search. We dealt with complaints about trying to chase down details that may or may not exist in a large body of literature in a case-by-case manner. Ultimately, the students developed searching strategies and were able to organize the information. The open-endedness of the project made creativity possible, which the students all seemed to enjoy.

An additional success indicator was increased office hour attendance. Students who previously had not shown excessive interest in course material began arriving early and asking questions. Several became quite stimulated by the topic and would engage each other in discussion about their models. These discussions provided an effective cooperative learning environment in which students relied on each other to learn and to teach the subject matter.[1]

Finally, students were both more creative in their problem solving and more expressive in the discussions of their models. This project was a success as a teaching tool because its open-endedness and active learning emphasis appealed to a wide variety of learning styles. The open-ended project was complimentary to more traditional problem sets in that it allowed students to extend their knowledge beyond what had been directly presented in the classroom.

CONCLUSIONS

Reactor design models can be successfully employed to model the guts of a variety of animals, and the use of such models on unique animal systems provides a stimulating learning experience for both the students and the instructor. We would encourage any one teaching a reactor design class to use this or a similar type of project to engage the students and help seize their interest.

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ChE book review

INTRODUCTION TO THEORETICAL AND COMPUTATIONAL FLUID DYNAMICS

by C. Pozrikidis

Published by Oxford University Press, 198 Madison Avenue, New York NY 10016; $75.00 (1996)

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Introduction to Theoretical and Computational Fluid Dynamics is an ambitious text, attempting and largely succeeding to encyclopedically cover the theoretical fundamentals of incompressible, nonturbulent Newtonian fluid mechanics. In addition, the book gives a flavor of the numerical methods by which fluid dynamics problems are often solved. The

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BOOK REVIEW: *Introduction to Theoretical and Computational Fluid Dynamics*

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emphasis of the book is strictly on fundamentals, particularly the general mathematical description of fluid motions and the presentation of solutions for important fundamental flow problems. The exposition is relatively abstract; little reference is made to applications, to experiments, or to observations of natural phenomena. In general, solutions to posed problems are obtained or outlined through exact analytical and numerical methods, primarily via singularity approaches or finite difference methods. This book contains a vast amount of detailed information, from the differential geometry of general surfaces in flow fields to the similarity solutions for Stokes flow near corners to the subtleties of the stability problem for inviscid shear flow.

The book begins with two excellent chapters on the kinematics of flows; of particular note are explicit general formulas for surface mean curvature and a collection of velocity fields determined by various vorticity distributions. The next chapter introduces stress and the equation of motion; nice features include a concise exposition of constitutive equations and a good discussion of vorticity transport; vorticity is a theme that receives a great deal of emphasis throughout the book. A brief chapter on hydrostatics follows, including many examples of the computation of static free surface shapes. Curiously, mean curvature is defined again, with no reference to Chapter 1.

Chapter 5 presents many of the classical exact solutions for viscous incompressible flow, including unidirectional flows, Jeffery-Hamel flow, stagnation point flows, and flows due to point sources.

Flow at low Reynolds numbers is the topic of Chapter 6. The primary emphasis is on singularity solutions of Stokes' equation, including a sketch of boundary-integral equation methods. A fairly detailed exposition of local solutions near corners is also given. Transient flow effects and the first effects of inertia are touched upon.

Chapters 7 and 8 describe irrotational flow and boundary layer theory, respectively. For irrotational flow, the basic results on force and torque exerted on a body in steady or time-dependent irrotational flow are described. Several pages are devoted to the use of conformal mapping for solving the Laplace equation. The chapter on boundary layers provides good coverage of the classical material. As in other places though, the author is sometimes overly terse here.

Chapter 9 is a very nice chapter on hydrodynamic stability, containing the basic results for shear flow, free surface, capillary, and centrifugal instabilities, though perhaps too brief regarding centrifugal instability. Noteworthy is the discussion of the concepts of absolute and convective instability and their relationship. It would have been nice, however, to see some generic results about nonlinearity, such as a brief discussion of supercritical and subcritical bifurcation.

Chapters 10 and 11 focus on the solution of inviscid flow problems. Chapter 10 outlines the boundary integral equation approach to the solution of potential flow problems, while Chapter 11 describes vortex motion in inviscid fluids, with the goal of providing the framework for numerical solution of vortex dynamics problems. Chapters 12 and 13 provide a whirlwind tour of finite-difference approaches to solving convection-diffusion and incompressible flow problems. One attractive feature of this section is the presentation of the modified differential equations associated with some of the approaches, showing, for example, that the instability of the FTCS scheme for a hyperbolic equation is traceable to an effective negative numerical diffusivity. Finally, two convenient appendices contain basic results in vector calculus and basic numerical methods.

There is clearly a great deal of material covered here, and covered well. Nevertheless, the breadth and depth of coverage has its cost. The text occasionally becomes an extended list of formulas, solutions, or methods. This is fantastic as a reference; I have used it repeatedly myself and referred parts of it to several graduate students. It is not always ideal for teaching purpose though, as the means by which solutions are obtained is often given little motivation. Details of solution procedures are often not provided, and sometimes opportunities to impart physical insight are bypassed in favor of a terse, elegant, mathematical statement or argument.

The level of mathematical sophistication assumed is at least that of a first-year grad student in chemical engineering, preferably one who has already taken an applied math class covering linear algebra and elementary partial differential equations. Because of the mathematical level of this book, the abstract point of view, and the sole emphasis on fundamentals, it is not appropriate as an undergraduate text for chemical engineering students. Nevertheless, it is probably a text that any serious student of fluid dynamics would like to own, and it would provide a good text for either an introductory or advanced graduate course in fluids, depending on the topics chosen. The lecturer will need to fill in many of the motivations and solution details, but this is not a large price to pay for a text that outlines theoretical fluid dynamics as thoroughly as this one does.

In my opinion, this is a very important contribution to the textbook literature in fluid dynamics—a book I am happy to own and one that I would highly recommend to anyone working in theoretical fluid dynamics. ❐