the "outer" world, the role of the sales department, some "bleak" aspects of industrial intelligence and what to do about it. The student carries out readings on the subject and responds to a questionnaire.

Research and Development • Formal definitions, assessment of R&D importance to industry, flow of information, and decisions on R&D are investigated. The student carries out some readings on the subject and a questionnaire is answered afterwards.

Law of Patents • What patents are, the requirements for patentability, limitations of the state on rights endowed by patents, patent regulations, and international agreements on patents are studied. Some discussions arise from questions by the students. The lecturer should be careful in distinguishing between awareness of the subject and technical expertise in legal matters befitting a patent attorney. The student reads the Law of Patents and other articles and is examined on the essentials of the subject.

Technology Transfer • The sale of know-how, and the main clauses of technological transfer agreements (subjects, ownerships, responsibilities, payments, procedures) are discussed. The same cautionary note to the lecturer on patents should apply here relative to contracts. The student reads a short patent (an agreement was also read in the two semester course) and answers a questionnaire requiring some literature search and some decisions of his own, which also cover preceding units.

Principles of Quality Control • Subjects reviewed are the "philosophy" of quality, the specifications of a product, what quality control is, some pitfalls in analysis, the clash of interests between buyers and sellers, contracts for the trade of chemicals, and what standards and standards organization are. In the two semester course some of the mathematics underlying sampling and acceptance-rejection decisions was learned. The student searches and reads Israeli and U.S. standards on an assigned chemical product and answers a questionnaire on the subject. In the two semester course he also solves some mathematical problems and is examined on the basics of quality control. □

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ChE book reviews

NUMERICAL METHODS AND MODELING FOR CHEMICAL ENGINEERS

By Mark E. Davis
John Wiley & Sons, Somerset, NJ 08873, $24.95 (1984)

Reviewed by
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Numerical Methods and Modeling for Chemical Engineers, by Mark E. Davis, provides a useful step beyond the standard undergraduate curriculum. One emphasis of the book is to teach chemical engineers how to use standard codes that are available for solving problems numerically. The book carefully lists the possible codes that are available and gives examples of their use. The use of standard codes is very important and this book emphasizes that aspect over generating a code to solve each problem yourself. The use of chemical engineering examples in the text and as problems is the book's strongest point.

The book does have some overall drawbacks that will limit its usefulness. The presentation of collocation is clouded by the notation and is needlessly complex. Orthogonal collocation is neglected altogether. Certainly this is unforgivable, given the widespread use of orthogonal collocation in chemical engineering. The Galerkin finite element method is never illustrated for a problem where the finite element method is needed or useful so that the reader is left to wonder why bother. While the treatment of ordinary differential equations is quite good, the treatment of partial differential equations is weak—it is far too limited with too few details. Some details needed to actually solve problems are left to the imagination and the scope of the methods (when they are useful) is not clear. For example, if one has a problem involving convection and diffusion and a high Peclet number, no mention is made of the numerical difficulties that are in store, or what impact that kind of a problem has on the choice of methods.

Chapter 1 discusses ordinary differential equations which are initial value problems. Treated there are the Euler method, Runge-Kutta methods, explicit and implicit methods. Stability is shown in detail for the simple methods and stated for other methods. The question of stiffness is considered, although the numerical criteria for what makes a problem stiff are taken without attribution from my own book. The discussion of step size adjustment in the codes is also modeled after my method applied to the Euler method. Overall, the reader is able to apply these methods.

Chapters 2 and 3 treat ordinary differential equations which are boundary value problems, while Chapters 4 and 5 treat partial differential equations. The transition from initial value methods in Chapter 1 is good and relies on shooting methods for solving boundary value problems.

The presentation of finite differences is a bare bones treatment with flux boundary conditions handled using only a fictitious point, and never a one-sided difference (sometimes it is important in more complicated problems to be able to use a one-sided difference). The integrated volume technique is presented and this is a good way to handle derivation of equations using a variable mesh. There is nothing on interpolation of the function between grid points, due to the decision in Chapter 1 to use Taylor series to present the ODEs rather than interpolation methods. This limits the user to examining the solution at the grid points. The presentation of the finite difference method applied to partial differential equations in one space and one time dimension is good, including treatment of implicit methods using the trapazoid rule. The effect of stability is clear only for one case and it is hard to generalize to other cases. This is one of those areas where the reader will need to consult other references. There are two important things left out: upwind differencing and adaptive mesh. Many problems now being solved include large convection effects along with diffusion effects. The reader is completely unaware of the numerical problems in store: how to solve them and the importance this has on the choice of method. In my book in 1980, I briefly mentioned adaptive mesh because it was an important new area. Much more should have been mentioned in a book published in 1984, since the role of adaptive mesh is now clear.

For elliptic problems the solution methods discussed are iterative: point iterative methods are discussed in the appendix and alternating direction methods are discussed in the text. Unfortunately, they are not tied together and the choice of iteration parameters is not displayed. Even though equations are shown for simple boundary conditions with irregular meshes, there is no discussion of the impact on the methods of solution, the bookkeeping associated with them, rates of convergence, or their generalization to more complicated boundary conditions. All of these factors are important when comparing the finite difference with the finite element method.

In the presentation of the collocation method, tensor methods are used over the whole space, thus limiting application to rectangular domains. This is a terrible limitation and newer work by George Pinder allows domains that have straight sides (easy to do) and also irregular domains. This newer work is ignored completely. This is another example of changes that should be made in a book published in 1984 over those published in 1980. In addition, orthogonal collocation is ignored despite its widespread use in chemical engineering for reaction-diffusion problems. For boundary value problems there is no reason given for the use of the Galerkin finite element method and the chapter ends by saying don't use it. For elliptic equations only regular domains are treated so that the power of the finite element method is not realized. Triangular grids are given which are inappropriate—there are points ending at the mid-point on the

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SPREADSHEETS

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sizes are linked to the fermentor size, it has been placed first in the list. The rest of the equipment specifications can be changed by entering the new specifications for the fermentor.

This type of table permits rapid computation of equipment costs for different plant capacities or for different fermentor sizes. For example, part of a design problem might be to find the optimum reactor size for a given capacity. The solution could include calculating equipment costs for several different reactor sizes, scheduling the reactors to plan the downtime, and determining overall process costs for each scenario. The student could then plot discrete solutions of cost versus reactor size to graphically determine a minimum cost reactor size.

MANUFACTURING COSTS

Table 4 shows the manufacturing costs for a phthalic anhydride process. Key process design factors (capacity, stream factor, and fixed capital) needed for computing fixed and variable costs are listed at the top. These factors are inputs to cost formulas throughout the table. This format allows the student to change the design basis rapidly.

The last column shows the contribution of each item to the manufacturing cost in cents per pound. This breakout is helpful for identifying high cost portions of the process and relating them to the selling price of the product. Listing the cost per unit as well as the quantity needed per year keeps the format flexible. It is simple to assess the sensitivity of the manufacturing costs to changes in raw material costs, labor costs, worker productivity and changes in process conversion.

We have found spreadsheet computations to be helpful to both students and instructors in the design courses. Spreadsheets require organization of the problem material and generate report-quality tables and figures. They help accomplish a rapid solution of the base case and speed analysis of process alternatives.

TABLE 4
Manufacturing Cost Table for a Phthalic Anhydride Process

Economic Example
Manufacturing Costs: Phthalic Anhydride

Capacity	7500 K lb/yr
Stream Factor	.95
Fixed Capital	12100 K $
Depreciable Cap	14900 K $

Variable Costs	**cts/Unit**	**Quantity/ Year**	**Cost, $/Yr**	**Cost, cts/lb**
Raw Materials				
O-Xylene, lbs	15.50	71250000	11043750	14.73
SO_2, lbs	6.50	375000	24375	.03
Sbtl			11068125	14.76
Catalyst, Chem.				
V_2O_5, lbs	720.00	18500	133200	.18
Ht. Trans. Salt, lbs	40.00	12500	5000	.01
N_2, M SCF	75.00	12000	9000	.01
Sbtl			147200	.20
Utilities				
Steam Credit, M lbs	110.00	−214000	−235400	−.31
H_2O, M Gals	20.00	33250	6650	.01
BFW Chem.	1.50	225000	3375	.00
Electricity, KWH	8.00	33750000	2700000	3.60
Sbtl			2474625	3.30
Subtotal, Variable Costs			13689950	18.25

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triangle. This is a terrible mesh and is not allowed in most codes. There is no discussion of natural boundary conditions which is a very important advantage of the finite element method for handling derivative boundary conditions, especially in semi-infinite domains since it reduces the computational costs significantly. Given this presentation of the finite element method, the reader will ask why. The book gives no answer other than that there are codes that are increasingly popular.

Despite these limitations, this is a reasonable treatment and is an improvement in the correct direction. However, the reader will find it necessary to consult other books to solve any problems that are significantly harder than those given in the examples. □