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Book Reviews

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Mathematical Modeling

Stefan Heinz, Springer–Verlag, Berlin 2011, 460 pp. $74.95

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Mathematical modeling, combined with computational simulation, has become an area of specialty in almost all disciplines: engineering, physics, chemistry, business, finance, economics, biology, psychology, and medicine, to name a few. At several universities, including mine, computational modeling and simulation (CMS) is now an independent major in which students can obtain a cross-disciplinary Ph.D. degree. The basic foundation for this degree is covered by mathematics and computer science course work; the remaining components are covered in other courses in the student's specialty area. I find this text very useful in our CMS program as it is accessible to almost all of the students, regardless of background. The text covers the modeling constituent only. Other courses (and texts) are required to cover the computational simulation component.

The book covers two primary types of modeling: deterministic and stochastic. These are covered in ten chapters with equal allocations to each of the two areas. Chapters 1–4 cover the fundamental characteristics of both types of modeling. Chapters 5–8 describe the evolution equations for univariate transport. Chapters 9–10 extend the analysis to multivariate systems. The concepts are presented such that they can be understood by readers with knowledge of elementary differential equations and linear algebra. All of the subsequent requisite mathematics and statistical analysis tools, including stochastic differential equations, random data analysis, and other concepts, are introduced in a very simple and step-bystep manner. These topics cover numerous subjects in mathematical & physical modeling. Examples include Buckingham theorem, Kepler's third law, Stokes law, probability density functions, Logistics equation, random walks, Brownian motion, Wiener processes, Kramers-Moyal equation, Pawula theorem, Lorentz equation, Fokker-Planck equation, Markovian processes, and many more. Diverse examples are taken from many disciplines such as population ecology, molecular transport, lake contamination, turbulent flows, heat & mass transfer, and more.

The text can be used for a course at the undergraduate or graduate level. In fact, there is sufficient material to cover two full courses, one at each level. I recommend coverage of the first five chapters in the first course and the remaining in the second. Alternatively, one could cover each of the two constituents in one semester each. If so, I recommend deterministic modeling be covered in the first course. This course would be particularly beneficial to students outside of science and engineering.

The book has several other pleasing features: conciseness of writing, clarity of figures, presentation of relevant examples, and inclusion of a large number of exercises at the end of each chapter. An instruction manual is also available that includes solutions to the exercise problems. The author has done a thorough job of solving the example problems, and the reader does not have to be a mathematical wizard to follow the derivations. However, some elementary knowledge of computer programming is required to follow the solution procedure in some of the examples and to solve some of the exercise problems.

Overall, I like this book and recommend it as a text in mathematical modeling. I also recommend it for those studying turbulent fluid mechanics, stochastic vibration & structures, noise, meteorology, random data management, and stock market analysis.

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