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Book Review

Helmut Neunzert and Abul Hasan Siddiqi *Topics in Industrial Mathematics. Case Studies and Related Mathematical Methods*. Applied Optimization, Vol. 42, Kluwer Academic Publishers, Dordrecht, Boston, London, October 2000, 388 pp. Hardbound, ISBN 0-7923-6417-1. EUR 136.00 / USD 159.00 / GBP 99.00. Available at a reduced price for course adoption when ordering six copies or more.

Several years before the disciplines of mathematics, from the one side, and of engineering, economics, ecology, medicine etc., from the other side, were divided by clear boundaries. Certainly, refined mathematical theories were developed for the description and the study of physical, social or financial effects and the results of these studies helped people enhance their knowledge. The field of classical mechanics, which traditionally posed many of the interesting questions in mathematics, constitutes a vivid example. Nevertheless, the restrictive assumptions, which were necessary to develop the 'theorems' and the limited ability to create meaningful results for real-life (thus, large-scale) applications underlined the previously mentioned borders. In order to create useful results one had to follow empirical methods. All applied scientists and engineers were therefore obliged to study separately the noble mathematical theories and, then, turn their attention to dirty empirical and descriptive methods for the solution of the problems posed by their clients. The role of the experiment in mechanical engineering or in physics demonstrates this need. The gap existed between molecular biology theories and the search for new medicaments is another example of this trend. Notable examples helped only underly this rule: architects and civil engineers must always design their creations before construction and, normally, they do not have the sources to test their products in a laboratory. Geometrical methods in statics and, later, computational science were used during the whole history of our civilization.

The continuous development of numerical methods and of computing systems changed the rule. With user-friendly and powerful computing tools, the tasks of modeling, discretization, analysis and visualization are within the reach of normal users. A new car is first created in the computer, using for example CAD (computer aided design) and FEM (finite element method, a multiphysics analysis method) software, its response in normal and extreme situations (e.g., crash tests) is predicted and optimized before constructions and, finally, some CAM (computer aided manufacturing) system is used for the automatic production of the separate components and their assembly. All these complicated software tools are based on

concrete mathematical models. Spesialised scientists must develop and maintain these highly sophisticated systems. Even the users, which are now free of the "monkey work", should have the ability to explain the results and use effectively all available tools. It is exactly this place where the industrial mathematician finds his place in the production procedure.

The book is based on the experience gained in the modeling seminar of Kaiserslautern and presents several aspects of industrial mathematics. Concrete applications demonstrate the application of mathematical theories and results. Tools from several branches of applied mathematics are outlined, so that more readers will find some topic close to their own work. In particular the book begins with some motivating case studies and then continues with discussion of the relevant topics in the subsequent chapters.

The concrete model-applications introduced in the first chapter concern: (i) the molecular alignment problem, a particular problem arising during drug design in the pharmaceutical industry which demonstrates some applications of Monte Carlo methods and optimization, (ii) the problem of acoustic identification of vehicles, where, among others, several notions of linear algebra, of Newton methods and of iterative procedures are mentioned, (iii) the modeling of an electromechanical airbag sensor, where one sees how methods of classical mechanics, which are based on Newton's second law of motion, or more complicated electromechanical models can be used for the design of a component which can save human lives, (iv) the quantitative automatic evaluation of the quality of nonwoven fabrics using images and methods of image processing and (v) the fatigue lifetime prediction, where a combination of classical mechanical models, including hysteresis, with data processing in the form of rainflow counting, is used for the prediction of the lifetime of a vehicle.

Each of the next five chapters is devoted to a topic of applied mathematics and has the form of a quick introduction to the corresponding field. Thus, Chapter two presents a short introduction to classical optimization, with topics like the Newton algorithm and its extensions, the conjugate gradient and the variable metric methods. The equations of electromagnetism, the so-called Maxwell's equations, are presented in Chapter three, together with a presentation of the corresponding variational formulation and an introduction to the numerical treatment using finite elements and boundary elements. The next chapter is devoted to Monte Carlo methods. Chapter five contains elements of image processing and Fourier, fractal and wavelet methods. Some elements of hysteresis modeling in mechanics are given in Chapter six. An appendix with various additional material, a list of 330 references, a list of symbols and a subject index accompany the work.

Certainly, the topic of applied mathematics is quite large and can not be covered in the limited space of a single monograph. Nevertheless, according to the reviewer's opinion, this book fulfills its purpose to be a "handy manual of mathematical methods for current industrial and technological problems which may be very useful for engineers and physicists". In this sense it is a useful addition to

applied mathematics and engineering libraries and may be used in graduate courses on “applied mathematics” or on “mathematical modeling”. The interested reader coming from the world of pure mathematics will profit from seeing a number of, even abstract, mathematical notions used for the design of industrial products and procedures, while engineering oriented readers will realize how complicated a real-world model may become and that, beyond some limits, serious mathematical skills must be developed or otherwise be available within a multidisciplinary working group.

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