Variational Methods with Applications in Science and Engineering

By Kevin W. Cassel

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There is an ongoing resurgence of applications in which the calculus of variations has direct relevance. *Variational Methods with Applications in Science and Engineering* reflects the strong connection between calculus of variations and the applications for which variational methods form the fundamental foundation. The material is presented in a manner that promotes development of an intuition about the concepts and methods with an emphasis on applications, and the priority of the application chapters is to provide a brief introduction to a variety of physical phenomena and optimization principles from a unified variational point of view. The first part of the book provides a modern treatment of the calculus of variations suitable for advanced undergraduate students and graduate students in applied mathematics, physical sciences, and engineering. The second part gives an account of several physical applications from a variational point of view, such as classical mechanics, optics and electromagnetics, modern physics, and fluid mechanics. A unique feature of this part of the text is derivation of the ubiquitous Hamilton's principle directly from the first law of thermodynamics, which enforces conservation of total energy, and the subsequent derivation of the governing equations of many discrete and continuous phenomena from Hamilton's principle. In this way, the reader will see how the traditional variational treatments of statics and dynamics are unified with the physics of fluids, electromagnetic fields, relativistic mechanics, and quantum mechanics through Hamilton's principle. The third part covers applications of variational methods to optimization and control of discrete and continuous systems, including image and data processing as well as numerical grid generation. The application chapters in parts two and three are largely independent of each other so that the instructor or reader can choose a path through the topics that aligns with their interests.

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Editorial Review

Review
"The upshot is that many current engineering students have never been properly exposed to the power and generality of variational methods.... In the course of reading the text, it becomes clear that the author has done an outstanding job in the organization and presentation of the application-oriented material. Cassel is sensitive to the learning style of his audience and puts a great deal of effort into motivating the material.... Overall, the text is clear and provides an excellent introduction to the calculus of variations for engineers and applied scientists looking for a concise exposition of the theory with numerous applications."

Joel Storch, IEEE Control Systems Magazine

"The current book is an attractive fresh look at the subject by a professor of mechanical and aerospace engineering ... Most chapters have a modest number of exercises. There is a very nice bibliography."
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"This well-written book contains a large amount of material ... will also be useful for scientists from application areas, in particular, those from engineering and physics."
Vicen?iu D. R?dulescu, Mathematical Reviews

About the Author

A graduate of Lehigh University and former National Research Council Postdoctoral Fellow at the National Institute of Standards and Technology (NIST), Kevin Cassel is Professor of Mechanical and Aerospace Engineering and Professor of Applied Mathematics at the Illinois Institute of Technology (IIT). He has been a visiting researcher at the University of Manchester, UK and University College London, UK and is a visiting professor at the University of Palermo, Italy. Professor Cassel has been teaching the course on which this book is based for the past fifteen years. His research utilizes computational fluid dynamics (CFD) in conjunction with advanced analytical methods to address problems in bio-fluids, unsteady aerodynamics, multiphase flow, and cryogenic fluid flow and heat transfer. Dr. Cassel is an Associate Fellow of the American Institute of Aeronautics and Astronautics (AIAA), and his honors include IIT's University Excellence in Teaching Award (2008) and Ralph L. Barnett Excellence in Teaching Award (2007, 2001), the 2002 Alfred Noble Prize, and the Army Research Office Young Investigator Award (1998-2001).

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