PREFACE

This book presents an investigative account of Mathematical Principles of Heat Transfer. It is concerned with three aspects of heat transfer analysis: theoretical development of conservation equations, analytical and numerical techniques of the solution, and the physical processes involved in the three basic modes of heat transfer, namely, conduction, convection, and radiation. A concept of mathematical modeling is developed through the use of differential equations. In doing so, the well-posed boundary value problems are constructed and the solutions are attempted.

The analytical solution techniques, such as separation of variables, Integral transforms, Green's function, and some approximate methods, e.g., the integral and variational methods, are described. The finite difference method for the partial differential equation is derived from the first principle. Convergence of the various difference schemes is established through solved examples. The stability and the compatibility of the difference schemes are discussed. For the sake of generality, one chapter is devoted to the similarity theory and the generalized variables; that enables presentation of the solution in the dimensionless form. The physical processes involved in the basic mode of heat transfer are described. The problems of steady and transient heat conduction are presented as boundary value problems and their solutions are obtained for a variety of geometrical shapes and boundary conditions. Also discussed is the process of heat conduction during melting or freezing. The fundamentals of convection are introduced and the equations for convective heat transfer are derived. With simplifications introduced by boundary layer approximations and considering the effects of turbulence, an attempt is made to model actual flow conditions. The process of free and forced convection is described and the problem of laminar free convection on a vertical surface is cast as a well-posed boundary value problem. The fundamental concept of radiative heat transfer is discussed and the method to find the radiative heat exchange between gray surfaces in an enclosure is outlined.

The text material is organized in such a way as to both give an exposure of practical thermal problems to applied mathematicians and introduce advanced mathematical techniques used in solving complex thermal problems to engineers. While emphasizing the formulation of the thermal problems and their solution procedures, the rigors of mathematical abstraction are avoided. In this way, the book attempts to bridge the gap between mathematicians and engineers. Further, a review of the recent literature on each topic and the references provided therein will trigger the curiosity of the reader and advance his understanding of the subject.

The book, designed for students and the research communities of engineering and applied mathematics, may also attract a wide range of readership from practicing mathematicians and engineers in industry.

It gives me great pleasure to acknowledge the help that I have received from a great

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Also, please note that the utmost care has been taken in checking the lengthy derivations, but it is quite possible that some of them might have gone unnoticed. I express my gratitude to the readers in advance for all suggestions for further improvement of the book.

K. N. Shukla
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