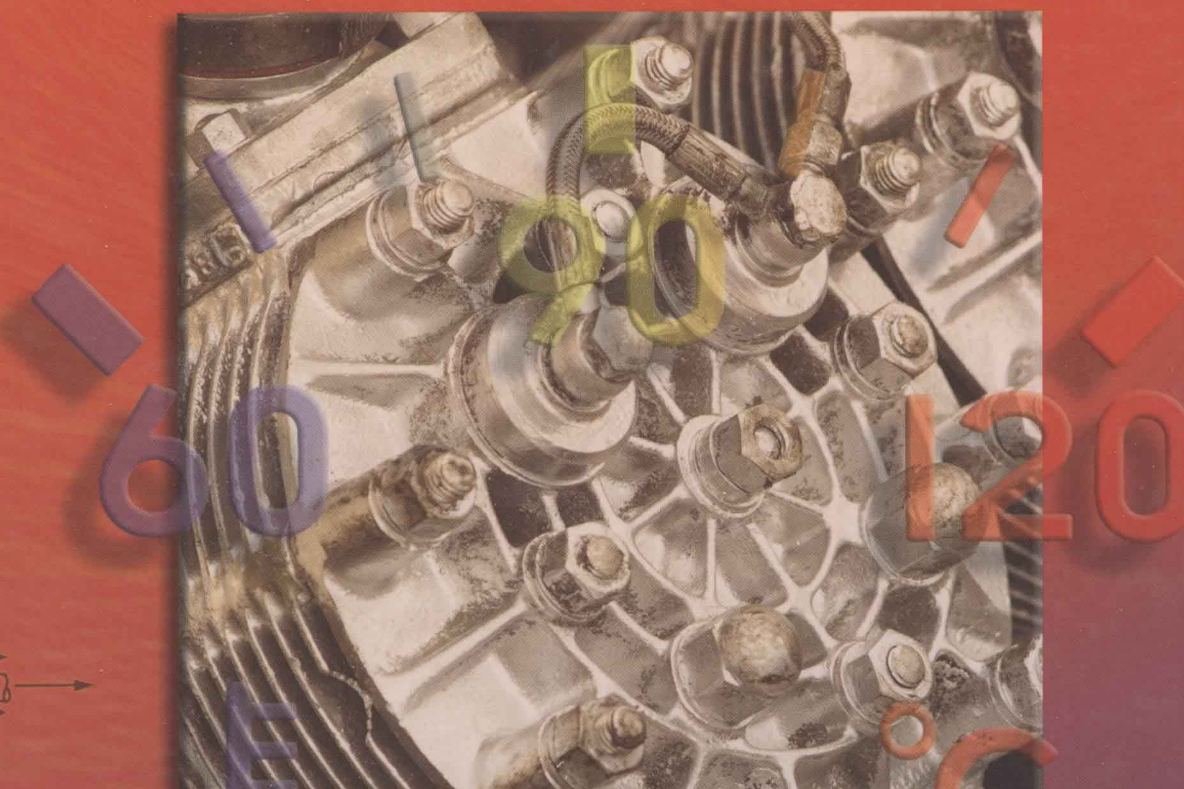
ENGINEERING HEAT TRANSFER

Third Edition



WILLIAM S. JANNA

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ENGINEERING HEAT TRANSFER

Third Edition

HEAT TRANSFER

A Series of Reference Books and Textbooks

SERIES EDITOR

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School of Mechanical and Aerospace Engineering
Oklahoma State University

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Dedication

To Him who is our source of love and knowledge

To Marla who transforms His love into strength

And to the reader for whom knowledge becomes wisdom

Preface

The philosophy of *Engineering Heat Transfer* is the same as it was when the book was first written—to write a readable, user-friendly book that provides many practical examples, without overwhelming the student. Many students think in concrete terms using pictures to envision what is being discussed. Thus drawings, sketches, graphs, etc., are used extensively in this book to enhance the learning process. Thinking in concrete terms is especially helpful in an area, such as heat transfer, which is highly abstract.

Every effort was made to provide many examples and a large number of confidence-building problems. The examples amplify the theory and show how the derived equations are used to model physical problems. Confidence-building problems are relatively simple and to some extent follow the examples. When a few of these types of problems are solved, the student will hopefully feel comfortable with the information and can then apply it with confidence to situations that are not obvious, and that increase in complexity. Problem solving is a skill that must be developed slowly, methodically, and thoroughly. The emphasis is on problems that are practical in nature. Applications of the material make this book interesting.

The new direction in engineering education is the implementation of "design throughout the curriculum." In addition, the design experience is meant to culminate in capstone courses, such as design of fluid thermal systems or mechanical design. Such necessary courses are taught at the senior level—either first or second semester. Moreover, these capstone design courses require knowledge of certain prerequisites such as fluid mechanics and heat transfer. In many curricula, heat transfer is taught at the junior or first semester-senior level. Rather than being a course in itself, it is now a backbone course for a senior design experience that is supposed to "put it all together." So the emphasis in this book is on problem-solving skills with real world examples. The niche that this book fills is that of a book written with practical applications in mind that can fit into the overall design experience. The time is right to move forward and keep pace with what is occurring in engineering education.

Text Modifications

The previous editions of this book had derivations of the Navier–Stokes equations in three coordinate systems. They also contained the derivations of the boundary layer equations, integral methods of solution, etc. As such, they were aimed originally at the senior mechanical engineering student who wanted to go to graduate school. The integral method for solution of the boundary layer equations, although interesting and clever, does not help a senior-level student learn how to design anything. Therefore, the current edition has been modified to make it better suited for an emerging place in the mechanical engineering curriculum. The objective here is to produce a revised book for a new market.

Chapter 1 of the third edition of *Engineering Heat Transfer* provides an introduction to heat transfer and to the tables at the end of this book. Chapter 2 discusses one-dimensional conduction. Heat flow through walls, cylinders, and fins are all considered.

Chapter 3 discusses steady-state conduction in multiple dimensions. The analytical method of solution applied to a simple problem is presented to illustrate the mathematical complexity of such problems. Next, alternative solution methods, including graphical and numerical methods, are presented. Much of the material in the first three chapters has been reorganized.

Chapter 4 discusses unsteady-state heat conduction, and it contains the lumped capacitance method as well as Heisler charts for more complex problems. Heisler charts have been modified to make them easier to read in the regions where the Fourier number is very small.

Chapter 5 provides an introduction to convection. A discussion of basic fluid mechanics is given, which serves as an overview of the convection chapters that follow. The Navier–Stokes equations are presented but not derived. The thermal energy equation is derived; however, the equations are used to solve problems in laminar flow for which there are exact solutions.

Chapter 6 discusses convection heat transfer in closed conduits. Circular and noncircular ducts are both discussed. Empirical correlations are also provided. Chapter 7 discusses convection heat transfer in flow past immersed bodies. Boundary layer flows are described but boundary layer equations are not derived. Descriptions and correlations are provided for various flows—flow over a flat plate, flow past two- and three-dimensional bodies, and flow past a bank of tubes.

Chapter 8 discusses natural convection. Problems considered are vertical surfaces, inclined surfaces, horizontal surfaces, cylinders, and arrays of fins. Chapter 9 discusses heat exchangers including double pipe, shell and tube, and cross flow. Both of these chapters are essentially unchanged from the previous edition.

Chapter 11 gives an introduction to radiation heat transfer. Topics include the electromagnetic radiation spectrum, emission and absorption, intensity, radiation laws, and characteristics of real surfaces. Chapter 12 discusses radiation heat transfer between surfaces. The view factor and methods for evaluating it are presented. Heat transfer within enclosures of black and gray surfaces is modeled.

Problems at the end of each chapter have been reorganized and classified according to the topic. In many cases, the instructor may not wish to cover certain sections in the chapter and such a reorganization makes it simple to select the desired problems appropriately.

The writing style conveys my enthusiasm for the material, and hopefully students will get as excited about solving heat transfer problems as I am.

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Author

Dr. William S. Janna received a BSME degree, an MSME, and a PhD from the University of Toledo. He joined the mechanical engineering faculty at The University of New Orleans in 1976, where he became department chair, and served in that position for 4 years. Subsequently, he joined The University of Memphis in 1987 as chair of the Department of Mechanical Engineering. Dr. Janna served as associate dean for graduate studies and research in the Herff College of Engineering. His research interests include boundary layer methods of solution for various engineering problems, modeling the melting of ice objects of various shapes, and the study of sublimation from various geometries. Dr. Janna is the author of three textbooks, and a member of the American Society of Mechanical Engineers (ASME). He teaches courses in heat transfer, fluid mechanics, and design of fluid/thermal systems. He has designed and constructed a number of experiments in fluid mechanics and heat transfer laboratories.

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