Fundamentals of Heat and Mass Transfer, 8th edition

by T.L. Bergman, A.S. Lavine, F.P. Incropera, and D.P. Dewitt · Language: EN

Overview

Fundamentals of Heat and Mass Transfer, 8th edition" by Bergman, Lavine, Incropera, and Dewitt is a foundational textbook designed to introduce undergraduate and graduate engineering students to the principles and applications of heat and mass transfer. The book systematically covers the three primary modes of heat transfer—conduction, convection, and radiation—along with an introduction to mass transfer. It emphasizes a rigorous, yet accessible, approach to understanding the physical mechanisms underlying these phenomena, providing a strong theoretical basis complemented by practical problem-solving methodologies.

The text is renowned for its clear explanations, comprehensive coverage, and extensive collection of illustrative examples and end-of-chapter problems, which range from fundamental concepts to complex engineering scenarios. It aims to equip students with the analytical tools necessary to model, analyze, and design systems involving thermal energy and mass transport. By integrating real-world applications and modern computational tools, the 8th edition continues to be an indispensable resource for students and professionals seeking a deep understanding of how heat and mass move through various systems, crucial for fields like mechanical, chemical, aerospace, and materials engineering.

Key Takeaways

- Heat transfer occurs through conduction, convection, and radiation, each governed by distinct physical laws and mechanisms.
- Understanding energy conservation is fundamental to analyzing any heat transfer problem, often expressed through control volume analysis.
- Boundary conditions are critical for solving heat transfer problems, defining the interactions between a system and its surroundings.
- Convection involves fluid motion and can be either forced (driven by external means) or natural (driven by buoyancy forces).
- Radiation heat transfer, unlike conduction and convection, does not require a medium and is significant at high temperatures or in a vacuum.

• Mass transfer, often analogous to heat transfer, describes the movement of chemical species within a mixture due to concentration gradients.

• Practical engineering design often involves optimizing heat exchangers and other thermal systems for efficiency and performance.

Chapter Summaries

Introduction

This chapter provides an essential overview of the modes of heat transfer, the significance of the subject in engineering, and fundamental concepts such as the first law of thermodynamics and conservation of energy. It establishes the foundational context and terminology necessary for the detailed analysis of heat and mass transfer processes presented throughout the book.

Introduction to Conduction

This section introduces Fourier's Law of Conduction, which quantifies heat transfer through materials. It covers the thermal properties of various materials and derives the general heat diffusion equation, establishing the mathematical framework required for analyzing heat transfer phenomena within solid bodies.

One-Dimensional, Steady-State Conduction

Focusing on simplified scenarios, this chapter details the solution of heat conduction problems in common geometries like plane walls, cylinders, and spheres under steady-state conditions. Key concepts include thermal resistance networks, which simplify complex systems, and the analysis of critical insulation thickness for optimal thermal design.

Two-Dimensional, Steady-State Conduction

This chapter addresses more intricate conduction problems that require consideration of heat flow in two spatial dimensions. It introduces advanced analytical methods such as separation of variables, graphical analysis using isotherms and adiabats, and the application of numerical techniques for complex geometries and boundary conditions.

Transient Conduction

This section deals with heat conduction problems where temperatures within a body change over time. It covers the lumped capacitance analysis for situations with negligible internal temperature gradients, explores spatial effects, and introduces the use of Heisler charts and numerical methods for more complex transient scenarios.

Introduction to Convection

This chapter defines convection as a mode of heat transfer involving fluid motion, differentiating between forced and natural convection. It introduces fundamental concepts such as boundary

layers, the Nusselt number, and the governing equations of fluid flow and energy, setting the stage for detailed convection analysis.

External Forced Convection

This section analyzes forced convection occurring over external surfaces, including flat plates, cylinders, and spheres. It provides empirical and theoretical correlations for calculating heat transfer coefficients in various flow regimes, enabling engineers to predict and design systems involving external fluid flow.

Internal Forced Convection

This chapter covers forced convection within confined geometries such as ducts and pipes. It examines phenomena like fully developed flow, thermal entry regions, and presents correlations for both laminar and turbulent flow heat transfer, crucial for designing piping systems and heat exchangers.

Free Convection

This section explores heat transfer driven by natural buoyancy forces, which arise from density differences caused by temperature variations in a fluid. It analyzes free convection on vertical and horizontal plates, cylinders, and spheres, providing methods for calculating heat transfer rates in such scenarios.

Heat Exchangers

This chapter is dedicated to the classification, analysis, and design of heat exchangers, devices crucial for transferring heat between two or more fluids. It covers the log mean temperature difference (LMTD) method and the effectiveness-NTU method for evaluating heat exchanger performance and sizing.

Radiation: Processes and Properties

This section introduces the fundamental principles of thermal radiation, a mode of heat transfer that does not require a medium. It covers concepts such as blackbody radiation, emissivity, absorptivity, reflectivity, transmissivity, and Kirchhoff's law, which are essential for understanding radiative heat exchange.

Diffusion Mass Transfer

This chapter presents the fundamentals of mass transfer, focusing on diffusion. It introduces Fick's Law of Diffusion, explains mass diffusion coefficients, and analyzes steady-state and transient mass diffusion in various engineering systems, often drawing analogies to heat transfer principles.

Themes

- Energy Transport Principles
- Thermal System Analysis
- Engineering Design Optimization
- Fluid Mechanics Interaction
- Material Thermal Behavior
- Transport Phenomena Modeling

Frequently Asked Questions

What is Fundamentals of Heat and Mass Transfer, 8th edition about?

This textbook provides a comprehensive introduction to the fundamental principles of heat and mass transfer, covering conduction, convection, radiation, and diffusion mass transfer. It teaches engineering students how to analyze, model, and design systems involving thermal energy and mass transport, with a strong emphasis on problem-solving.

Is Fundamentals of Heat and Mass Transfer, 8th edition worth reading?

For engineering students and professionals in fields like mechanical, chemical, and aerospace engineering, this book is highly regarded as a definitive and essential resource. Its clear explanations, rigorous approach, and extensive problem sets make it invaluable for mastering the core concepts of heat and mass transfer.

Who should read Fundamentals of Heat and Mass Transfer, 8th edition?

The primary audience for this book is undergraduate and graduate students in engineering disciplines such as mechanical, chemical, aerospace, and materials engineering. It is also a valuable reference for practicing engineers who need to apply heat and mass transfer principles in their professional work.

How long does it take to read Fundamentals of Heat and Mass Transfer, 8th edition?

Given its depth and comprehensive nature, reading this textbook thoroughly, including working through examples and problems, can take several months of dedicated study. For a typical student, it represents a semester-long course commitment, implying hundreds of hours of engagement.