analysis of transport phenomena

Analysis of Transport Phenomena: A Comprehensive Guide

Introduction:

Have you ever wondered how heat dissipates from a hot object, how fluids flow through pipes, or how substances diffuse through a membrane? These seemingly disparate processes are all governed by the principles of transport phenomena – a fundamental area of study with far-reaching implications across numerous fields, from chemical engineering and materials science to environmental engineering and biomedicine. This comprehensive guide delves into the analysis of transport phenomena, providing a detailed overview of the core concepts, methodologies, and applications. We'll unpack the fundamental equations, explore diverse analytical techniques, and showcase real-world examples to illustrate the practical relevance of this crucial subject. Prepare to gain a deeper understanding of the forces shaping the movement of mass, momentum, and energy within various systems.

1. Fundamental Concepts: Defining Mass, Momentum, and Energy Transport

Transport phenomena fundamentally deals with the transport of three conserved quantities: mass, momentum, and energy. Let's define each:

Mass Transport (Diffusion): This refers to the net movement of mass from a region of high concentration to a region of low concentration. This can occur via various mechanisms, including molecular diffusion (random motion of molecules), convection (bulk fluid motion), and migration (movement under the influence of external fields). Fick's Law provides a mathematical description of diffusion.

Momentum Transport (Fluid Mechanics): This involves the transfer of momentum within a fluid, leading to viscous forces and fluid flow. Newton's Law of Viscosity describes the relationship between shear stress and velocity gradient within a fluid. Understanding momentum transport is crucial in areas like fluid dynamics, lubrication, and the design of pipelines and pumps.

Energy Transport (Heat Transfer): This encompasses the transfer of thermal energy from a higher temperature region to a lower temperature region. This can occur via conduction (molecular vibrations), convection (fluid motion), and radiation (electromagnetic waves). Fourier's Law describes the conduction of heat, while other equations govern convection and radiation.

1. Governing Equations: The Mathematical Framework of Transport Phenomena

Analyzing transport phenomena requires a strong mathematical foundation. Several fundamental equations govern the transport processes:

Conservation Equations: These equations express the principle of conservation of mass, momentum, and energy. They are based on the idea that these quantities cannot be created or destroyed, only transferred. These equations are often expressed in differential form, requiring advanced mathematical techniques for solutions.

Constitutive Equations: These equations relate the fluxes (rates of transport) of mass, momentum, and energy to the driving forces. For example, Fick's Law is a constitutive equation relating the mass flux to the concentration gradient. Similarly, Newton's Law of Viscosity and Fourier's Law are constitutive equations for momentum and energy transport, respectively.

Boundary Conditions: These conditions specify the values of the dependent variables (e.g., concentration, velocity, temperature) at the boundaries of the system under consideration. The appropriate boundary conditions are crucial for obtaining physically meaningful solutions.

1. Analytical Techniques: Solving the Governing Equations

Solving the governing equations of transport phenomena can be challenging, often requiring sophisticated analytical techniques. Common methods include:

Analytical Solutions: For simplified geometries and boundary conditions, analytical solutions can be obtained. These solutions provide valuable insights into the underlying physics and can serve as benchmarks for more complex numerical methods.

Numerical Methods: For more complex geometries and boundary conditions, numerical methods are necessary. Finite difference, finite element, and finite volume methods are commonly used to discretize the governing equations and obtain approximate solutions. Computational Fluid Dynamics (CFD) is a powerful tool utilizing these methods for simulating fluid flow and heat transfer.

Dimensional Analysis: This technique allows for scaling and simplification of the governing equations by identifying dimensionless groups that govern the behavior of the system. This can significantly reduce the computational cost and improve understanding of the dominant physical processes.

1. Applications Across Diverse Fields:

The principles of transport phenomena find widespread applications in various fields:

Chemical Engineering: Reactor design, separation processes, mixing, and process optimization heavily rely on an understanding of mass, momentum, and energy transport.

Materials Science: Understanding diffusion processes is critical for material synthesis, characterization, and processing. The mechanical properties of materials are also closely linked to momentum transport at the microstructural level.

Environmental Engineering: Pollutant dispersion modeling, groundwater flow analysis, and air pollution control all involve the application of transport phenomena principles.

Biomedicine: Drug delivery systems, understanding blood flow, and oxygen transport in the body are examples of biomedical applications relying on transport phenomena.

1. Advanced Topics: Beyond the Basics

Advanced topics in transport phenomena include:

Turbulence: Understanding turbulent flow is crucial in many engineering applications. Turbulent flow is characterized by chaotic and unpredictable fluid motion, requiring advanced modeling techniques.

Multiphase Flow: Many industrial processes involve the flow of multiple phases (e.g., gas-liquid, liquid-liquid). Analyzing these systems requires specialized models that account for the interactions between the phases.

Coupled Transport Phenomena: In many real-world systems, different transport phenomena are coupled. For example, heat transfer can influence fluid flow, and fluid flow can influence mass transport. Modeling these coupled phenomena requires more sophisticated techniques.

Sample Textbook Outline: "Introduction to Transport Phenomena"

Introduction: Overview of transport phenomena, fundamental concepts, and applications.
Chapter 1: Conservation Equations: Derivation and application of mass, momentum, and energy conservation equations.
Chapter 2: Constitutive Equations: Detailed discussion of Fick's Law, Newton's Law of Viscosity, and Fourier's Law.
Chapter 3: Analytical Solutions: Solving simplified transport problems analytically.
Chapter 4: Numerical Methods: Introduction to finite difference, finite element, and finite volume methods.
Chapter 5: Applications in Chemical Engineering: Examples of transport phenomena in reactors, separation processes, and mixing.
Chapter 6: Applications in other fields: Exploration of applications in materials science, environmental engineering, and biomedicine.
Chapter 7: Advanced Topics: Discussion of turbulence, multiphase flow, and coupled transport phenomena.
Conclusion: Summary of key concepts and future directions in transport phenomena research.

(Detailed explanation of each chapter would follow here, expanding on the points mentioned in the outline. This would add another substantial portion to the article, easily exceeding the 1500-word mark.)

FAQs:

1. What is the difference between conduction, convection, and radiation? Conduction is heat transfer through direct contact, convection involves heat transfer through fluid motion, and radiation involves heat transfer through electromagnetic waves.

1. What is Fick's Law? Fick's Law describes the diffusion of a substance, stating that the flux is proportional to the concentration gradient.

1. What is Newton's Law of Viscosity? Newton's Law of Viscosity relates shear stress to the velocity gradient in a fluid.

1. What is Fourier's Law? Fourier's Law describes the conduction of heat, stating that the heat flux is proportional to the temperature gradient.

1. What are the common numerical methods used to solve transport phenomena problems? Finite difference, finite element, and finite volume methods are commonly used.

1. What is Computational Fluid Dynamics (CFD)? CFD is a powerful computational technique used to simulate fluid flow and heat transfer.

1. What are some real-world applications of transport phenomena? Applications include reactor design, drug delivery, pollution dispersion modeling, and more.

1. What are some advanced topics in transport phenomena? Advanced topics include turbulence, multiphase flow, and coupled transport phenomena.

1. Where can I find more information on transport phenomena? Numerous textbooks, research articles, and online resources are available.

Related Articles:

1. Introduction to Fluid Mechanics: A basic overview of fluid behavior and fundamental equations.
2. Heat Transfer Fundamentals: A detailed explanation of conduction, convection, and radiation.
3. Mass Transfer Operations: An exploration of various mass transfer processes in chemical engineering.
4. Numerical Methods in Engineering: A survey of numerical techniques used to solve engineering problems.
5. Computational Fluid Dynamics (CFD) Applications: Case studies showcasing CFD's use in various industries.
6. Turbulence Modeling in CFD: An in-depth look at turbulence modeling techniques.
7. Multiphase Flow Modeling: An overview of methods for simulating flows with multiple phases.
8. Diffusion in Solids: An examination of diffusion processes within solid materials.
9. Transport Phenomena in Biological Systems: A look at the role of transport phenomena in biological processes.

This expanded outline provides a framework for a comprehensive blog post on the analysis of transport phenomena. Remember to expand upon each point with detailed explanations, examples, and relevant visuals to create an engaging and informative piece for your readers. The key is to maintain clarity, use relevant keywords naturally, and provide valuable information that satisfies search intent.

analysis of transport phenomena: *Analysis of Transport Phenomena* William Murray Deen, 2012 Analysis of Transport Phenomena, Second Edition, provides a unified treatment of momentum, heat, and mass transfer, emphasizing the concepts and analytical techniques that apply to these transport processes. The second edition has been revised to reinforce the progression from simple to complex topics and to better introduce the applied mathematics that is needed both to understand classical results and to model novel systems. A common set of formulation, simplification, and solution methods is applied first to heat or mass transfer in stationary media and then to fluid mechanics, convective heat or mass transfer, and systems involving various kinds of coupled fluxes. FEATURES: * Explains classical methods and results, preparing students for engineering practice and more advanced study or research * Covers everything from heat and mass transfer in stationary media to fluid mechanics, free convection, and turbulence * Improved organization, including the establishment of a more integrative approach * Emphasizes concepts and analytical techniques that apply to all transport processes * Mathematical techniques are introduced more gradually to provide students with a better foundation for more complicated topics discussed in later chapters

analysis of transport phenomena: *Analysis of Transport Phenomena* William M. Deen, 2012-09-06 Deen's first edition has served as an ideal text for graduate level transport courses within chemical engineering and related disciplines. It has successfully communicated the fundamentals of transport processes to students with its clear presentation and unified treatment of momentum, heat, and mass transfer, and its emphasis on the concepts and analytical techniques that apply to all of these transport processes. This text includes distinct features such as mathematically self-contained discussions and a clear, thorough discussion of scaling principles and dimensional analysis. This new edition offers a more integrative approach, covering thermal conduction and diffusion before fluid mechanics, and introducing mathematical techniques more gradually, to provide students with a better foundation for more advanced problems later on. It also provides a broad range of new, real-world examples and exercises, which reflects the current shifts of emphasis within chemical engineering practice and research to biological applications, microsystem technologies, membranes, think films, and interfacial phenomena. Finally, this edition includes a new appendix with a concise review of how to solve the differential equations most commonly encountered transport problems.

analysis of transport phenomena: Analysis of Transport Phenomena William M. Deen, 1998-03-26 Analysis of Transport Phenomena is intended mainly as a text for graduate-level courses in transport phenomena for chemical engineers. Among the analytical methods discussed are scaling, similarity, perturbation, and finite Fourier transform techniques. The physical topics include conduction and diffusion in stationary media, fluid mechanics, forced- and free-convection heat and mass transfer, and multicomponent energy and mass transfer.

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analysis of transport phenomena: Advanced Transport Phenomena L. Gary Leal, 2007-06-18 Advanced Transport Phenomena is ideal as a graduate textbook. It contains a detailed discussion of modern analytic methods for the solution of fluid mechanics and heat and mass transfer problems, focusing on approximations based on scaling and asymptotic methods, beginning with the derivation of basic equations and boundary conditions and concluding with linear stability theory. Also covered are unidirectional flows, lubrication and thin-film theory, creeping flows, boundary layer theory, and convective heat and mass transport at high and low Reynolds numbers. The emphasis is on basic physics, scaling and nondimensionalization, and approximations that can be used to obtain solutions that are due either to geometric simplifications, or large or small values of dimensionless parameters. The author emphasizes setting up problems and extracting as much information as possible short of obtaining detailed solutions of differential equations. The book also focuses on the solutions of representative problems. This reflects the book's goal of teaching readers to think about the solution of transport problems.

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analysis of transport phenomena: Transport Phenomena for Chemical Reactor Design Laurence A. Belfiore, 2003-04-11 Laurence Belfiore’s unique treatment meshes two mainstream subject areas in chemical engineering: transport phenomena and chemical reactor design. Expressly intended as an extension of Bird, Stewart, and Lightfoot’s classic Transport Phenomena, and

Froment and Bischoff’s Chemical Reactor Analysis and Design, Second Edition, Belfiore’s unprecedented text explores the synthesis of these two disciplines in a manner the upper undergraduate or graduate reader can readily grasp. Transport Phenomena for Chemical Reactor Design approaches the design of chemical reactors from microscopic heat and mass transfer principles. It includes simultaneous consideration of kinetics and heat transfer, both critical to the performance of real chemical reactors. Complementary topics in transport phenomena and thermodynamics that provide support for chemical reactor analysis are covered, including: Fluid dynamics in the creeping and potential flow regimes around solid spheres and gas bubbles The corresponding mass transfer problems that employ velocity profiles, derived in the book’s fluid dynamics chapter, to calculate interphase heat and mass transfer coefficients Heat capacities of ideal gases via statistical thermodynamics to calculate Prandtl numbers Thermodynamic stability criteria for homogeneous mixtures that reveal that binary molecular diffusion coefficients must be positive In addition to its comprehensive treatment, the text also contains 484 problems and ninety-six detailed solutions to assist in the exploration of the subject. Graduate and advanced undergraduate chemical engineering students, professors, and researchers will appreciate the vision, innovation, and practical application of Laurence Belfiore’s Transport Phenomena for Chemical Reactor Design.

analysis of transport phenomena: Advanced Transport Phenomena John C. Slattery, 1999-07-13 The term 'transport phenomena' describes the fundamental processes of momentum, energy, and mass transfer. This text provides a thorough discussion of transport phenomena, laying the foundation for understanding a wide variety of operations used by chemical engineers. The book is arranged in three parallel parts covering the major topics of momentum, energy, and mass transfer. Each part begins with the theory, followed by illustrations of the way the theory can be used to obtain fairly complete solutions, and concludes with the four most common types of averaging used to obtain approximate solutions. A broad range of technologically important examples, as well as numerous exercises, are provided throughout the text. Based on the author's extensive teaching experience, a suggested lecture outline is also included. This book is intended for first-year graduate engineering students; it will be an equally useful reference for researchers in this field.

analysis of transport phenomena: Special Topics in Transport Phenomena G. Astarita, R. Ocone, 2001-12-21 This book is a research monograph on transport phenomena. The topics discussed are often mathematically simple, though conceptually complex. The book is written in a colloquial style which a good teacher uses in the classroom. It originates from the author's wealth of teaching experience in this area and incorporates suggestions from colleagues worldwide.

analysis of transport phenomena: Transport Phenomena in Porous Media Yasuaki Ichikawa, A.P.S. Selvadurai, 2012-02-10 This monograph presents an integrated perspective of the wide range of phenomena and processes applicable to the study of transport of species in porous materials. In order to formulate the entire range of porous media and their uses, this book gives the basics of continuum mechanics, thermodynamics, seepage and consolidation and diffusion, including multiscale homogenization methods. The particular structure of the book has been chosen because it is essential to be aware of the true properties of porous materials particularly in terms of nano, micro and macro mechanisms. This book is of pedagogical and practical importance to the fields covered by civil, environmental, nuclear and petroleum engineering and also in chemical physics and geophysics as it relates to radioactive waste disposal, geotechnical engineering, mining and petroleum engineering and chemical engineering.

analysis of transport phenomena: Interfacial Transport Phenomena John C. Slattery, Leonard Sagis, 2013-04-17 Transport phenomena is used here to descril>e momentum, energy, mass, and entropy transfer (Bird et al. 1960, 1980). It includes thermodynamies, a special case of which is thermostatics. Interfacial transport phenomena refers to momentum, energy , mass, and entropy transfer within the immediate neighborhood of a phase interface, including the thermodynamies of the interface. In terms of qualitative physical observations, this is a very old field. Pliny the EIder

(Gaius Plinius Secundus, 23-79 A.D.; Pliny 1938) described divers who released small quantities of oil from their mouths, in order to damp capillary ripples on the ocean surface and in this way provide more uniform lighting for their work. Similar stories were retold by Benjamin Franklin, who conducted experiments of his own in England (V an Doren 1938). In terms of analysis, this is a generally young field. Surface thermostatics developed relatively early, starting with Gibbs (1948) and continuing with important contributions by many others (see Chapter 5).

analysis of transport phenomena: Transport Phenomena in Partially Ionized Plasma V.A. Rozhansky, L.D. Tsendin, 2001-11-22 Transport phenomena in plasmas are the relatively slow processes of particle momentum and energy transport systems in a state of mechanical equilibrium. In contrast to neutral gases, these phenomena in plasmas are greatly influenced by self-consistent fields, in particular electric fields. These can produce particle and energy fluxes, in addition to those generated by the inhomogeneity of the plasma composition and temperature. As a result, the physical effects accompanying transport phenomena in plasmas are far more numerous and complicated than those in neutral gases, and the solution of corresponding problems is more difficult. The effects, however, are usually far more interesting and sometimes surprising. This book presents a systematic survey and analysis of the main mechanisms of transport phenomena in plasma and gives examples of gradually increasing complexity to illustrate these mechanisms and the relationships between them. The author pays special attention to the analysis of experimental measurements and considers the relevant processes analytically as well as qualitatively. The majority of problems dealt with in this book are of considerable practical interest, and the phenomena described often determine the main characteristics of processes and devices. Transport Phenomena in Partially Ionized Plasma will be of interest to researchers who need to know the properties of real, specific systems, as well as to engineers and advanced students in the physics of plasmas, semiconductors, various types of gas discharges and the ionosphere.

analysis of transport phenomena: Computational Transport Phenomena for Engineering Analyses Richard C. Farmer, Ralph W. Pike, Gary C. Cheng, Yen-Sen Chen, 2009-06-03 Although computer technology has dramatically improved the analysis of complex transport phenomena, the methodology has yet to be effectively integrated into engineering curricula. The huge volume of literature associated with the wide variety of transport processes cannot be appreciated or mastered without using innovative tools to allow comprehen

analysis of transport phenomena: Transport Phenomena Larry A. Glasgow, 2010-12-01 Enables readers to apply transport phenomena principles to solve advanced problems in all areas of engineering and science This book helps readers elevate their understanding of, and their ability to apply, transport phenomena by introducing a broad range of advanced topics as well as analytical and numerical solution techniques. Readers gain the ability to solve complex problems generally not addressed in undergraduate-level courses, including nonlinear, multidimensional transport, and transient molecular and convective transport scenarios. Avoiding rote memorization, the author emphasizes a dual approach to learning in which physical understanding and problem-solving capability are developed simultaneously. Moreover, the author builds both readers' interest and knowledge by: Demonstrating that transport phenomena are pervasive, affecting every aspect of life Offering historical perspectives to enhance readers' understanding of current theory and methods Providing numerous examples drawn from a broad range of fields in the physical and life sciences and engineering Contextualizing problems in scenarios so that their rationale and significance are clear This text generally avoids the use of commercial software for problem solutions, helping readers cultivate a deeper understanding of how solutions are developed. References throughout the text promote further study and encourage the student to contemplate additional topics in transport phenomena. Transport Phenomena is written for advanced undergraduates and graduate students in chemical and mechanical engineering. Upon mastering the principles and techniques presented in this text, all readers will be better able to critically evaluate a broad range of physical phenomena, processes, and systems across many disciplines.

analysis of transport phenomena: *Advances in Transport Phenomena in Porous Media* Jacob

Bear, M.Y. Corapcioglu, 2012-12-06 This volume contains the lectures presented at the NATO ADVANCED STUDY INSTITUTE that took place at Newark, Delaware, U. S. A. , July 14-23, 1985. The objective of this meeting was to present and discuss selected topics associated with transport phenomena in porous media. By their very nature, porous media and phenomena of transport of extensive quantities that take place in them, are very complex. The solid matrix may be rigid, or deformable (elastically, or following some other constitutive relation), the void space may be occupied by one or more fluid phases. Each fluid phase may be composed of more than one component, with the various components capable of interacting among themselves and/or with the solid matrix. The transport process may be isothermal or non-isothermal, with or without phase changes. Porous medium domains in which extensive quantities, such as mass of a fluid phase, component of a fluid phase, or heat of the porous medium as a whole, are being transported occur in the practice in a variety of disciplines.

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analysis of transport phenomena: Transport Phenomena in Biomedical Engineering Robert A. Peattie, Robert J. Fisher, Joseph D. Bronzino, Donald R. Peterson, 2012-11-20 Design, analysis and simulation of tissue constructs is an integral part of the ever-evolving field of biomedical engineering. The study of reaction kinetics, particularly when coupled with complex physical phenomena such as the transport of heat, mass and momentum, is required to determine or predict performance of biologically-based systems wheth

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analysis of transport phenomena: Transport Phenomena with Drops and Bubbles Satwindar

S. Sadhal, Portonovo S. Ayyaswamy, Jacob N. Chung, 2012-12-06 Fluid flows that transfer heat and mass often involve drops and bubbles, particularly if there are changes of phase in the fluid in the formation or condensation of steam, for example. Such flows pose problems for the chemical and mechanical engineer significantly different from those posed by single-phase flows. This book reviews the current state of the field and will serve as a reference for researchers, engineers, teachers, and students concerned with transport phenomena. It begins with a review of the basics of fluid flow and a discussion of the shapes and sizes of fluid particles and the factors that determine these. The discussion then turns to flows at low Reynolds numbers, including effects due to phase changes or to large radial inertia. Flows at intermediate and high Reynolds numbers are treated from a numerical perspective, with reference to experimental results. The next chapter considers the effects of solid walls on fluid particles, treating both the statics and dynamics of the particle-wall interaction and the effects of phase changes at a solid wall. This is followed by a discussion of the formation and breakup of drops and bubbles, both with and without phase changes. The last two chapters discuss compound drops and bubbles, primarily in three-phase systems, and special topics, such as transport in an electric field.

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analysis of transport phenomena: Environmental Transport Phenomena A. Eduardo Saez, James C. Baygents, 2014-12-01 This book offers a detailed yet accessible introduction to transport phenomena. It begins by explaining the underlying principles and mechanisms that govern mass transport, and continues by tackling practical problems spanning all subdisciplines of environmental science and chemical engineering. Assuming some knowledge of ordinary differential equations and a familiarity with basic fluid mechanics applications, this classroom-tested text addresses mass conservation and macroscopic mass balances, placing a special emphasis on applications to environmental processes and presenting a mathematical framework for formulating and solving transport phenomena problems.

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analysis of transport phenomena: Transport Phenomena in Micro Process Engineering Norbert Kockmann, 2007-11-12 In this book, the fundamentals of chemical engineering are presented with respect to applications in micro system technology, microfluidics, and transport processes within microstructures. Special features of the book include the state-of-the-art in micro process engineering, a detailed treatment of transport phenomena for engineers, and a design methodology from transport effects to economic considerations.

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analysis of transport phenomena: A Modern Course in Transport Phenomena David C. Venerus, Hans Christian Öttinger, 2018-03-15 Integrating nonequilibrium thermodynamics and kinetic theory, this unique text presents a novel approach to the subject of transport phenomena.

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analysis of transport phenomena: *Introduction to Modeling of Transport Phenomena in Porous Media* Jacob Bear, Y. Bachmat, 2012-12-06 The main purpose of this book is to provide the theoretical background to engineers and scientists engaged in modeling transport phenomena in porous media, in connection with various engineering projects, and to serve as a text for senior and graduate courses on transport phenomena in porous media. Such courses are taught in various disciplines, e. g. , civil engineering, chemical engineering, reservoir engineering, agricultural engineering and soil science. In these disciplines, problems are encountered in which various extensive quantities, e. g. , mass and heat, are transported through a porous material domain. Often the porous material contains several fluid phases, and the various extensive quantities are transported simultaneously throughout the multiphase system. In all these disciplines, management decisions related to a system's development and its operation have to be made. To do so, the 'manager', or the planner, needs a tool that will enable him to forecast the response of the system to the implementation of proposed management schemes. This forecast takes the form of spatial and temporal distributions of variables that describe the future state of the considered system. Pressure, stress, strain, density, velocity, solute concentration, temperature, etc. , for each phase in the system, and sometime for a component of a phase, may serve as examples of state variables. The tool that enables the required predictions is the model. A model may be defined as a simplified version of the real (porous medium) system that approximately simulates the excitation-response relations of the latter.

analysis of transport phenomena: Modeling Transport Phenomena in Porous Media with Applications Malay K. Das, Partha P. Mukherjee, K. Muralidhar, 2017-11-21 This book is an ensemble of six major chapters, an introduction, and a closure on modeling transport phenomena in porous media with applications. Two of the six chapters explain the underlying theories, whereas the rest focus on new applications. Porous media transport is essentially a multi-scale process. Accordingly, the related theory described in the second and third chapters covers both continuum- and meso-scale phenomena. Examining the continuum formulation imparts rigor to the empirical porous media models, while the mesoscopic model focuses on the physical processes within the pores. Porous media models are discussed in the context of a few important engineering applications. These include biomedical problems, gas hydrate reservoirs, regenerators, and fuel cells. The discussion reveals the strengths and weaknesses of existing models as well as future research directions.

analysis of transport phenomena: Transport Phenomena in Multiphase Flows Roberto Mauri, 2015-04-08 This textbook provides a thorough presentation of the phenomena related to the transport of mass, momentum and energy. It lays all the basic physical principles, then for the more advanced readers, it offers an in-depth treatment with advanced mathematical derivations and ends with some useful applications of the models and equations in specific settings. The important idea behind the book is to unify all types of transport phenomena, describing them within a common framework in terms of cause and effect, respectively represented by the driving force and the flux of the transported quantity. The approach and presentation are original in that the book starts with a general description of transport processes, providing the macroscopic balance relations of fluid dynamics and heat and mass transfer, before diving into the mathematical realm of continuum mechanics to derive the microscopic governing equations at the microscopic level. The book is a modular teaching tool and can be used either for an introductory or for an advanced graduate course. The last 6 chapters will be of interest to more advanced researchers who might be interested in particular applications in physics, mechanical engineering or biomedical engineering. All chapters are complemented with exercises that are essential to complete the learning process.

analysis of transport phenomena: Introduction to Transport Phenomena William J. Thomson, 2000 Professor William J. Thomson emphasizes the formulation of differential equations to describe physical problems, helping readers understand what they are doing - and why. The solutions are either simple (separable, linear second order) or derivable with a differential equation solver.--BOOK JACKET.

analysis of transport phenomena: Transport Phenomena Estéban Saatdjian, 2000-11-08 This invaluable text, provides a much-needed overview of both the theoretical development, as well as appropriate numerical solutions, for all aspects of transport phenomena. It contains a basic introduction to many aspects of fluid mechanics, heat transfer and mass transfer, and the conservation equations for mass, energy and momentum are discussed with reference to engineering applications. Heat transfer by conduction, radiation, natural and forced convection is studied, as well as mass transfer and incompressible fluid mechanics. The second part of the book deals with numerical methods used to solve the problems encountered earlier. The basic concepts of finite difference and finite volume methods are presented. Other subjects usually covered in mathematical textbooks such as vector and tensor analysis, Laplace transforms, and Runge-Kutta methods are discussed in the Appendices. * Offers comprehensive coverage of both transport phenomena and numerical and analytical solutions to the problems. * Includes comprehensive coverage of numerical techniques. * Provides real-life problems and solutions, which are vital to the understanding and implementation of applications. This work will be welcomed not only by senior and graduate students in mechanical, aeronautical and chemical engineering, but also for engineers practising in these fields.

analysis of transport phenomena: Transport Phenomena Fundamentals Joel L. Plawsky, 2020-02-27 The fourth edition of Transport Phenomena Fundamentals continues with its streamlined approach to the subject, based on a unified treatment of heat, mass, and momentum transport using a balance equation approach. The new edition includes more worked examples within each chapter and adds confidence-building problems at the end of each chapter. Some numerical solutions are included in an appendix for students to check their comprehension of key concepts. Additional resources online include exercises that can be practiced using a wide range of software programs available for simulating engineering problems, such as, COMSOL®, Maple®, Fluent, Aspen, Mathematica, Python and MATLAB®, lecture notes, and past exams. This edition incorporates a wider range of problems to expand the utility of the text beyond chemical engineering. The text is divided into two parts, which can be used for teaching a two-term course. Part I covers the balance equation in the context of diffusive transport—momentum, energy, mass, and charge. Each chapter adds a term to the balance equation, highlighting that term's effects on the physical behavior of the system and the underlying mathematical description. Chapters familiarize students with modeling and developing mathematical expressions based on the analysis of a control volume, the derivation of the governing differential equations, and the solution to those equations with appropriate boundary conditions. Part II builds on the diffusive transport balance equation by introducing convective transport terms, focusing on partial, rather than ordinary, differential equations. The text describes paring down the full, microscopic equations governing the phenomena to simplify the models and develop engineering solutions, and it introduces macroscopic versions of the balance equations for use where the microscopic approach is either too difficult to solve or would yield much more information that is actually required. The text discusses the momentum, Bernoulli, energy, and species continuity equations, including a brief description of how these equations are applied to heat exchangers, continuous contactors, and chemical reactors. The book introduces the three fundamental transport coefficients: the friction factor, the heat transfer coefficient, and the mass transfer coefficient in the context of boundary layer theory. Laminar flow situations are treated first followed by a discussion of turbulence. The final chapter covers the basics of radiative heat transfer, including concepts such as blackbodies, graybodies, radiation shields, and enclosures.

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