

Table of Contents

- 1 Introduction and Some Useful Review
- A Message for the Student
- Differential Equations
- Classification of Partial Differential Equations and Boundary Conditions
- Numerical Solutions for Partial Differential Equations
- Vectors, Tensors, and the Equation of Motion
- The Men for Whom the Navier-Stokes Equations are Named
- Sir Isaac Newton
- References
- 2 Inviscid Flow Simplified Fluid Motion
- Introduction
- Two-Dimensional Potential Flow
- Numerical Solution of Potential Flow Problems
- Circulation and the Kutta-Joukowski theorem
- Conclusion
- References
- 3 Laminar Flows in Ducts and Enclosures
- Introduction
- Hagen-Poiseuille Flow
- Transient Hagen-Poiseuille Flow
- Poiseuille Flow in an Annulus
- Ducts with Other Cross-Sections
- Combined Couette and Poiseuille Flows
- Couette Flows in Enclosures
- Generalized Two-Dimensional Fluid Motion in Ducts
- Some Concerns in Computational Fluid Mechanics
- Flow in the Entrance of Ducts
- Creeping Fluid Motions in Ducts and Cavities
- Microfluidics Flow in Very Small Channels
- Flows in Open Channels
- Pulsatile Flows in Cylindrical Ducts
- Conclusion
- References
- 4 External Laminar Flows and Boundary-Layer Theory
- Introduction
- The Flat Plate
- Flow Separation Phenomena about Bluff Bodies
- Boundary Layer on a Wedge the Falkner-Skan Problem
- The Free Jet
- Integral Momentum Equations
- Hiemenz Stagnation Flow
- Flow in the Wake of a Flat Plate at Zero Incidence
- Conclusion
- References

- 5 Instability, Transition, and Turbulence
 - Introduction
 - Linearized Hydrodynamic Stability Theory
 - Inviscid Stability, the Rayleigh Equation
 - Stability of Flow between Concentric Cylinders
 - Transition
 - Transition in Hagen-Poiseuille flow
 - Transition for the Blasius case
 - Turbulence and Elementary Closure Schemes
 - Higher order closure schemes
 - Variations
 - Introduction to the Statistical Theory of Turbulence
 - Conclusion
 - References
- 6 Heat Transfer by Conduction
 - Introduction
 - Steady-State Conduction Problems in Rectangular Coordinates
 - Transient Conduction Problems in Rectangular Coordinates
 - Steady-State Conduction Problems in Cylindrical Coordinates
 - Transient Conduction Problems in Cylindrical Coordinates
 - Steady-State Conduction Problems in Spherical Coordinates
 - Transient Conduction Problems in Spherical Coordinates
 - Kelvin's Estimate of the Age of the Earth
 - Some Specialized Topics in Conduction
 - Conduction in extended surface heat transfer
 - Anisotropic materials
 - Composite spheres
 - Conclusion
 - References
- 7 Heat Transfer with Laminar Fluid Motion
 - Introduction
 - Problems in Rectangular Coordinates
 - Couette flow with thermal energy production
 - Viscous heating with temperature-dependent viscosity
 - The thermal entrance region in rectangular coordinates
 - Heat transfer to fluid moving past a flat plate
 - Problems in Cylindrical Coordinates
 - Thermal entrance length in a tube the Graetz problem
 - Natural Convection Buoyancy-Induced Fluid Motion
 - Vertical heated plate the Pohlhausen problem
 - The heated, horizontal cylinder
 - Natural convection in enclosures
 - Two-dimensional Rayleigh-Benard problem
 - Conclusion
 - References
- 8 Diffusional Mass Transfer

- Introduction
- Unsteady Evaporation of Volatile Liquids the Arnold Problem
- Diffusion in Rectangular Geometries
- Diffusion into quiescent liquids absorption
- Absorption with chemical reaction
- Concentration-dependent diffusivity
- Diffusion through a membrane
- Diffusion through a membrane with variable D
- Diffusion in Cylindrical Systems
- The isothermal, cylindrical catalyst pellet
- Diffusion in squat (small L/d) cylinders
- Diffusion through membrane with edge effects
- Diffusion in Spherical Systems
- The spherical catalyst pellet with exothermic reaction
- Sorption into a sphere from a solution of limited volume
- Some Specialized Topics in Diffusion
- Diffusion with moving boundaries
- Diffusion with impermeable obstructions
- Diffusion in biological systems
- Conclusion
- References
- 9 Mass Transfer in Well-Characterized Flows
- Introduction
- Convective Mass Transfer in Rectangular Coordinates
- Thin film on a vertical wall
- Convective transport with reaction at wall
- Mass transfer between a flowing fluid and a flat plate
- Mass Transfer with Laminar Flow in Cylindrical Systems
- Fully developed flow in a tube
- Variations for mass transfer in a cylindrical tube
- Mass transfer in an annulus with laminar flow
- Homogeneous reaction in fully-developed laminar flow
- Mass Transfer between a Sphere and a Moving Fluid
- Some Specialized Topics in Convective Mass Transfer
- Using oscillatory flows to enhance interphase transport
- Chemical vapor deposition in horizontal reactors
- Dispersion effects in chemical reactors
- Transient operation of a tubular reactor
- Conclusion
- References
- 10 Heat and Mass Transfer in Turbulence
- Introduction
- Solution through Analogy
- Elementary Closure Processes
- Scalar Transport with Two-Equation Models of Turbulence
- Turbulent Flows with Chemical Reactions

- Simple closure schemes
- An Introduction to pdf Modeling
- The Fokker-Planck equation and pdf modeling of reactive flows
- Transported pdf modeling
- The Lagrangian View of Turbulent Transport
- Conclusion
- References
- 11 Topics in Multiphase and Multicomponent Systems
 - Gas-Liquid Systems
 - Gas bubbles in liquids
 - Bubble formation at orifices
 - Bubble oscillations and mass transfer
 - Liquid-Liquid Systems
 - Droplet breakage
 - Particle-Fluid Systems
 - Introduction to coagulation
 - Collision mechanisms
 - Self-preserving size distributions
 - Dynamic behavior of the particle size distribution
 - Other aspects of PSD modeling
 - A highly simplified example
 - Multicomponent Diffusion in Gases
 - The Stefan-Maxwell equations
 - Conclusion
 - References
- Problems to Accompany A Second Course in Transport Phenomena
- Appendix A Finite Difference Approximations for Derivatives
- Appendix B Bessel's Equation and Bessel Functions
- Appendix C Solving Laplace and Poisson (Elliptic) Partial Differential Equations
- Appendix D Solving Elementary Parabolic Partial Differential Equations
- Appendix E Error Function
- Appendix F Gamma Function
- Appendix G Regular Perturbation
- Appendix H Solution of Differential Equations by Collocation