Wilcox Turbulence Modeling For Cfd Solution Manual

Table of contents

This is an advanced textbook on the subject of turbulence, and is suitable for engineers, physical scientists and applied mathematicians. The aim of the book is to bridge the gap between the elementary accounts of turbulence found in undergraduate texts, and the more rigorous monographs on the subject. Throughout, the book combines the maximum of physical insight with the minimum of mathematical detail. Chapters 1 to 5 may be appropriate as background material for an advanced undergraduate or introductory postgraduate course on turbulence, while chapters 6 to 10 may be suitable as background material for an advanced postgraduate course on turbulence, or act as a reference source for professional researchers. This second edition covers a decade of advancement in the field, streamlining the original content while updating the sections where the subject has moved on. The expanded content includes large-scale dynamics, stratified & rotating turbulence, the increased power of direct numerical simulation, two-dimensional turbulence, Magnetohydrodynamics, and turbulence in the core of the Earth

This book outlines the computational fluid dynamics evolution and gives an overview of the methods available to the engineer.

Modelling and Computation of Turbulent Flows has been written by one of the most prolific authors in the field of CFD. Professor of aerodynamics at SUPAERO and director of DMAE at ONERA, the author calls on both his academic and industrial experience when presenting this work. The field of CFD is strongly represented by the following corporate companies; Boeing; Airbus; Thales; United Technologies and General Electric, government bodies and academic institutions also have a strong interest in this exciting field. Each chapter has also been specifically constructed to constitute as an advanced textbook for PhD candidates working in the field of CFD, making this book essential reading for researchers, practitioners in industry and MSc and MEng students. * A broad overview of the development and application of Computational Fluid Dynamics (CFD), with real applications to industry * A Free CD-Rom which contains computer program ' s suitable for solving non-linear equations which arise in modeling turbulent flows * Professor Cebeci has published over 200 technical papers and 14 books, a world authority in the field of CFD

Turbulent Jets

Automata, Languages and Computation

Analysis of the K-Epsilon Turbulence Model

Progress in Hybrid RANS-LES Modelling

Theory of Computer Science

This unique text provides engineering students and practicing professionals with a comprehensive set of practical, hands-on guidelines and dozens of step-by-step examples for performing state-of-the-art, reliable computational fluid dynamics (CFD) and turbulence modeling. Key CFD and turbulence programs are included as well. The text first reviews basic CFD theory, and then details advanced applied t turbulence, including new algorithms created by the author. The book gives practical advice on selecting appropriate turbulence models and presents best CFD practices for modeling and generating reliable simulations. The author gathered and developed the book's hundreds of tips, tricks, and examples over three decades of research and development at three national laboratories and at the University of for the first time in this book. The book also places a strong emphasis on recent CFD and turbulence advancements found in the literature over the past five to 10 years. Readers can apply the author's advice and insights whether using commercial or national laboratory software such as ANSYS Fluent, STAR-CCM, COMSOL, Flownex, SimScale, OpenFOAM, Fuego, KIVA, BIGHORN, or their own computa

Computational Fluid Dynamics and Turbulence Modeling is a practical, complementary companion for academic CFD textbooks and senior project courses in mechanical, civil, chemical, and nuclear engineering; senior undergraduate and graduate CFD and turbulence modeling courses; and for professionals developing commercial and research applications.

"Describes the latest techniques and real-life applications of computational fluid dynamics (CFD) and heat transfer in aeronautics, materials processing and manufacturing, electronic cooling, and environmental control. Includes new material from experienced researchers in the field. Complete with detailed equations for fluid flow and heat transfer.

This book allows readers to tackle the challenges of turbulent flow problems with confidence. It covers the fundamentals of turbulence, various modeling approaches, and experimental studies. The fundamentals section includes isotropic turbulence and anistropic turbulence, turbulent flow dynamics, free shear layers, turbulent boundary layers and plumes. The modeling section focuses on topics such as ed E Models, Direct Numerical Stimulation, Large Eddy Simulation, and their applications. The measurement of turbulent fluctuations experiments in isothermal and stratified turbulent flows are explored in the experimental methods section. Special topics include modeling of near wall turbulent flows, compressible turbulent flows, and more.

We are delighted to present this book which contains the Proceedings of the Fifth International Conference on Computational Fluid Dynamics (ICCFD5), held in Seoul, Korea from July 7 through 11, 2008. The ICCFD series has established itself as the leading international conference series for scientists, mathematicians, and engineers specialized in the computation of fluid flow. In ICCFD5, 5 Invited Lectur were delivered by renowned researchers in the areas of innovative modeling of flow physics, innovative algorithm development for flow simulation, optimization and control, and advanced multidisciplinary - plications. There were a total of 198 contributed abstracts submitted from 25 countries. The executive committee consisting of C. H. Bruneau (France), J. J. Chattot (USA), D. Kwak (USA), N. Satofuka (Ja responsible for selection of papers. Each of the members had a separate subcommittee to carry out the evaluation. As a result of this careful peer review process, 138 papers were accepted for oral presentation and 28 for poster presentation. Among them, 5 (3 oral and 2 poster presentation) papers were withdrawn and 10 (4 oral and 6 poster presentation) papers were not presented. The conference was a 23 countries. The technical aspects of the conference were highly beneficial and informative, while the non-technical aspects were fully enjoyable and memorable. In this book, 3 invited lectures and 1 keynote lecture appear first. Then 99 c- tributed papers are grouped under 21 subject titles which are in alphabetical order.

Analysis of Turbulent Flows with Computer Programs

An Introduction for Scientists and Engineers

Turbulence

Mass Transfer

Computational Models for Turbulent Reacting Flows

In this Special Issue, one review paper highlights the necessity of multiscale CFD, coupling micro- and macro-scales, for exchanging information at the interface of the two scales. Four research papers investigate the hydrodynamics, heat transfer, and chemical reactions of various processes using Eulerian CFD modeling. CFD models are attractive for industrial applications. However, substantial efforts in physical modeling and numerical implementation are still required before their widespread implementation.

Most natural and industrial flows are turbulent. The atmosphere and oceans, automobile and aircraft engines, all provide examples of this ubiquitous phenomenon. In recent years, turbulence has become a very lively area of scientific research and application, and this work offers a grounding in the subject of turbulence, developing both the physical insight and the mathematical framework needed to express the theory. Providing a solid foundation in the key topics in turbulence, this valuable reference resource enables the reader to become a knowledgeable developer of predictive tools. This central and broad ranging topic would be of interest to graduate students in a broad range of subjects, including aeronautical and mechanical engineering, applied mathematics and the physical sciences. The accompanying solutions manual to the text also makes this a valuable teaching tool for lecturers and for practising engineers and scientists in computational and experimental and experimental fluid dynamics.

Basics of Engineering Turbulence introduces flow turbulence to engineers and engineering students who have a fluid dynamics background, but do not have advanced knowledge on the subject. It covers the basic characteristics of flow turbulence in terms of its many scales. The author uses a pedagogical approach to help readers better understand the fundamentals of turbulence scales, especially how they are derived through the order of magnitude analysis. This book is intended for those who have an interest in flowing fluids. It provides some background, though of limited scope, on everyday flow turbulence, especially in engineering applications. The book begins with the 'basics' of turbulence which is necessary for any reader being introduced to the subject, followed by several examples of turbulence in engineering applications. This overall approach gives readers all they need to grasp both the fundamentals of turbulence and its applications in practical instances. Focuses on the basics of turbulence for applications in engineering and industrial settings Provides an understanding of concepts that are often challenging, such as energy distribution among the turbulent structures, the effective diffusivity, and the theory behind turbulence scales Offers a user-friendly approach with clear-and-concise explanations and illustrations, as well as end-of-chapter problems

Uniquely outlines CFD theory in a manner relevant to environmental applications. This book addresses the basic topics in CFD modelling in a thematic manner to provided the necessary theoretical background, as well as providing global cases studies showing how CFD models can be used in practice demonstrating how good practice can be achieved , with reference to both established and new applications. First book to apply CFD to the environmental sciences Written at a level suitable for non-mathematicians

Large-Eddy Simulation for Acoustics

An Introductory Text for Graduate Engineering Students

Statistical Theory and Modeling for Turbulent Flows

Statistical Turbulence Modelling for Fluid Dynamics — Demystified

Computational Fluid Dynamics 2000

These proceedings contain the papers presented at the 4th International Symposium on Engineering Turbulence Modelling and Measurements held at Ajaccio, Corsica, France from 24–26 May 1999. It follows three previous conferences on the topic of engineering turbulence modelling and measurements. The purpose of this series of symposia is to provide a forum for presenting and discussing new developments in the area of turbulence modelling and measurements, with particular emphasis on engineering-related problems. Turbulence is still one of the key issues in tackling engineering flow problems. As powerful computers and accurate numerical methods are now available for solving the flow equations, and since engineering applications nearly always involve turbulence effects, the reliability of CFD analysis depends more and more on the performance of the turbulence models. Successful simulation of turbulence requires the understanding of the complex physical phenomena involved and suitable models for describing the turbulent momentum, heat and mass transfer. For the understanding of turbulence phenomena, experiments are indispensable, but they are equally important for providing data for the development and testing of turbulence models and hence for CFD software validation.

Providing invaluable information for both graduate researchers and R & D engineers in industry and consultancy, this book focuses on the modelling and simulation of fluid flow and thermal transport phenomena in turbulent convective flows. Its overall objective is to present state-of-the-art knowledge in order to predict turbulent heat transfer processes in fundamental and idealized flows as well as in engineering applications. The chapters, which are invited contributions from some of the most prominent scientists in this field, cover a wide range of topics and follow a unified outline and presentation to aid accessibility.

This title provides the fundamental bases for developing turbulence models on rational grounds. The main different methods of approach are considered, ranging from statistical modelling at various degrees of complexity to numerical simulations of turbulence. Each of these various methods has its own specific performances and limitations, which appear to be complementary rather than competitive. After a discussion of the basic concepts, mathematical tools and methods for closure, the book considers second order closure models. Emphasis is placed upon this approach because it embodies potentials for clarifying numerous problems in turbulent shear flows. Simpler, generally older models are then presented as simplified versions of the more general second order models. The influence of extra physical parameters is also considered. Finally, the book concludes by examining large Eddy numerical simulations methods. Given the book's comprehensive coverage, those involved in the theoretical or practical study of turbulence problems in fluids will find this a useful and informative read.

Noise pollution around airports, trains, and industries increasingly attracts environmental concern and regulation. Designers and researchers have intensified the use of large-eddy simulation (LES) for noise reduced industrial design and acoustical research. This 2007 book, written by 30 experts, presents the theoretical background of acoustics and of LES, followed by details about numerical methods, e.g. discretization schemes, boundary conditions, coupling aspects. Industrially relevant, hybrid RANS/LES techniques for acoustic source predictions are presented in detail. Many applications are featured ranging from simple geometries for mixing layers and jet flows to complex wing and car geometries. Selected applications include scientific investigations at industrial and university research institutions.

Second-Moment Routes to Closure

Advancement in Process Modelling

Modeling and Simulation of Turbulent Flows

Theory, Computation and Applications

This book is intended to be used as a textbook for a first course in fluid mechanics. It stresses on principles and takes the students through the various development in theory and applications. A number of exercises are given at the end of each chapter, all of which have been successfully class-tested by the authors. It will be ideally suited for students taking an undergraduate degree in engineering in all universities in India.

This book is intended for self-study or as a companion of lectures delivered to post-graduate students on the subject of the computational prediction of complex turbulent flows. There are several books in the extensive literature on turbulence that deal, in statistical terms, with the phenomenon itself, as well its many manifestations in the context of fluid dynamics. Statistical Turbulence Modelling for Fluid Dynamics — Demystified differs from these and focuses on the physical interpretation of a broad range of mathematical models used to represent the time-averaged effects of turbulence in computational prediction schemes for fluid flow and related transport processes in engineering and the natural environment. It dispenses with complex mathematical manipulations and instead gives physical and phenomenological explanations. This approach allows students to gain a 'feel' for the physical fabric represented by the mathematical structure that describes the effects of turbulence and the models embedded in most of the software currently used in practical fluid-flow predictions, thus counteracting the ill-informed black-box approach to turbulence modelling. This is done by taking readers through the physical arguments underpinning exact concepts, the rationale of approximations of processes that cannot be retained in their exact form, and essential calibration steps to which the resulting models are subjected by reference to theoretically established behaviour of, and experimental data for, key canonical flows. Contents: Statistical Viewpoint of Turbulence — Motivation and RationaleWhat Makes Turbulence Tick?Reynolds-AveragingFundamentals of Stress / Strain InteractionFundamentals of Near-Wall InteractionsFundamentals of Scalar-Flux / Scalar-Gradient InteractionsThe Eddy ViscosityOne-Equation Eddy-Viscosity ModelsTwo-Equation ModelsWall Functions For Linear Eddy-Viscosity ModelsDefects of Linear Eddy-Viscosity Models, Their Sources and (Imperfect) Corrections Reynolds-Stress-Transport ModellingScalar/Heat-Flux-Ttransport ModellingThe ˜υ2 — ƒ ModelAlgebraic Reynolds-Stress and Non-Linear Eddy-Viscosity Models Readership: Researchers and post-graduate students in the field of fluid dynamics. Key Features:Emphasis on physical and phenomenological interpretationBroad range of models coveredStrong emphasis on understanding the concepts and the rationale behind assumptionsAvoidance of mathematical complexity that does not serve the objective of conveying understanding and insightKeywords:Turbulence Modeling;Rans;Computational Fluid Dynamics;Single Point Closure

This volume contains contributions to the BRITE-EURAM 3rd Framework Programme ETMA and extended articles of the TMA-Workshop. It focusses on turbulence modelling techniques suitable to use in typical flow configurations, with emphasis on compressibility effects and inherent unsteadiness. These methodologies are applied to the Navier-Stokes equations, involving various turbulence modelling levels from algebraic to RSM. Basic turbulent flows in aeronautics are considered; mixing layers, wall-flows (flat-plate, backward-facing step, ramp, bump), and more complex configurations (bump, aerofoil). A critical assessment of the turbulence modelling performances is offered, based on previous results and on the experimental data-base of this research programme. The ETMA results figure in the data-base constituted by all partners and organized by INRIA

Modelling transport and mixing by turbulence in complex flows is one of the greatest challenges for CFD. This highly readable volume introduces the reader to a level of modelling that respects the complexity of the physics of turbulent flows – second-moment closure. Following introductory chapters providing essential physical background, the book examines in detail the processes to be modelled, from fluctuating pressure interactions to diffusive transport, from turbulent time and length scales to the handling of the semi-viscous region adjacent to walls. It includes extensive examples ranging from fundamental homogeneous flows to three-dimensional industrial or environmental applications. This book is ideal for CFD users in industry and academia who seek expert guidance on the modelling options available, and for graduate students in physics, applied mathematics and engineering who wish to enter the world of turbulent flow CFD at the advanced level.

Advanced Computational Fluid and Aerodynamics

Papers Contributed to the 4th Symposium on Hybrid RANS-LES Methods, Beijing, China, September 2011

Turbulence Modeling for CFD

For Power, Energy and Flight

CFD Module

Large Eddy Simulations (LES) are beginning to emerge as the state-of-the art for turbulence modeling in Computational Fluid Dynamics (CFD), but due to current computational constraints, the need will continue to exist for a lower fidelity, yet robust set of Reynolds-Averaged Navier- Stokes (RANS) turbulence models. Many of these turbulence models are based off of the classic Boussinesq approximation which relates the mean flow stresses to the turbulent eddy viscosity. The traditional Boussinesq approximation relies upon the instantaneous strain rate which may produce large errors in solutions for flows with significant changes in strain (such as areas of massive separation and re-attachment). The unstructured Navier-Stokes solver AVUS is modified using a new method developed by Peter E. Hamlington and Werner J. A. Dahm which replaces the classic Boussinesq approximation with a new non-equilibrium closure technique. The new non-equilibrium k omega turbulence model modification takes into account the time history of the strain rate by modifying the eddy viscosity term found in the k omega Wilcox turbulence model. Computational results from this new model are compared to experimental data from numerous test cases which include a two-dimensional flat plate, NACA 0012 airfoil, RAE 2822 transonic airfoil, and a fully three-dimensional unmanned aerial vehicle. The results of the new model are encouraging since they are more closely correlating to experimental data.

Aimed at applied mathematicians interested in the numerical simulation of turbulent flows. Centered around the k-&epsis; model, it also deals with other models such as one equation models, subgrid scale models and Reynolds Stress models. Presents the k-&epsis; method for turbulence in a language familiar to applied mathematicians, but has none of the technicalities of turbulence theory.

Turbulence Modeling for CFDSolutions ManualTurbulence Modeling for CFDD C W IndustriesTurbulence Modeling for CFD: CD-ROMImplementation and Validation of a Modified Non-equilibrium Wilcox K Omega Turbulence Model in Subsonic and Transonic Flow Regimes

The present book contains contributions presented at the Fourth Symposium on Hybrid RANS-LES Methods, held in Beijing, China, 28-30 September 2011, being a continuation of symposia taking place in Stockholm (Sweden, 2005), in Corfu (Greece, 2007), and Gdansk (Poland, 2009). The contributions to the last two symposia were published as NNFM, Vol. 97 and Vol. 111. At the Beijing symposium, along with seven invited keynotes, another 46 papers (plus 5 posters) were presented addressing topics on Novel turbulence-resolving simulation and modelling, Improved hybrid RANS-LES methods, Comparative studies of difference modelling methods, Modelling-related numerical issues and Industrial applications.. The present book reflects recent activities and new progress made in the development and applications of hybrid RANS-LES methods in general.

Practical Tools, Tips and Techniques

Computational Fluid Dynamics (CFD) of Chemical Processes

Discontinuous Galerkin Methods

Computational Fluid Dynamics: Principles and Applications

Fundamentals, Experiments and Modeling

Computational Fluid Dynamics (CFD) is an important design tool in engineering and also a substantial research tool in various physical sciences as well as in biology. The objective of this book is to provide university students with a solid foundation for understanding the numerical methods employed in today ' s CFD and to familiarise them with modern CFD codes by hands-on experience. It is also intended for engineers and scientists starting to work in the field of CFD or for those who apply CFD codes. Due to the detailed index, the text can serve as a reference handbook too. Each chapter includes an extensive bibliography, which provides an excellent basis for further studies.

Turbulent Jets

This book covers the major problems of turbulence and turbulent processes, including physical phenomena, their modeling and their simulation. After a general introduction in Chapter 1 illustrating many aspects dealing with turbulent flows, averaged equations and kinetic energy budgets are provided in Chapter 2. The concept of turbulent viscosity as a closure of the Reynolds stress is also introduced. Wall-bounded flows are presented in Chapter 3 and aspects specific to boundary layers and channel or pipe flows are also pointed out. Free shear flows, namely free jets and wakes, are considered in Chapter 4. Chapter 5 deals with vortex dynamics. Homogeneous turbulence, isotropy and dynamics of isotropic turbulence are presented in Chapters 6 and 7. Turbulence is then described both in the physical space and in the wave number space. Time dependent numerical simulations are presented in Chapter 8, where an introduction to large eddy simulation is offered. The last three chapters of the book summarize remarkable digital techniques current and experimental. Many results are presented in a practical way, based on both experiments and numerical simulations. The book is written for a advanced engineering students as well as postgraduate engineers and researchers. For students, it contains the essential results as well as details and demonstrations whose oral transmission is often tedious. At a more advanced level, the text provides numerous references which allow readers to find quickly further study regarding their work and to acquire a deeper knowledge on topics of interest.

This book can be used as a reference for the topic of turbulence modeling, especially in an engineering modeling and simulation course or as a tool for professionals on practical applications. Turbulent flow modeling has many applications in industry. The relevant numerical methods have advanced to the level that could be used by industry professionals to model many natural turbulent flows with acceptable accuracy. In this book we cover the fundamentals of turbulence, modeling techniques, and algorithms (including RANS) available in COMSOL ® as well as providing several modeling examples and instructions for building these models. The companion DVD includes models and figures discussed in the book. eBook Customers: Companion files are available for downloading with order number/proof of purchase by writing to the publisher at info@merclearning.com. Features: • Includes companion DVD with models and figures discussed in the book • Explains the physics and principles of turbulence and provides modeling examples using COMSOL

Basics of Engineering Turbulence

Applications in Environmental Hydraulics

Computational Fluid Mechanics and Heat Transfer

Engineering Turbulence Modelling and Experiments - 4

Solutions Manual

Publisher Description

A class of finite element methods, the Discontinuous Galerkin Methods (DGM), has been under rapid development recently and has found its use very quickly in such diverse applications as aeroacoustics, semi-conductor device simula tion, turbomachinery, turbulent flows, materials processing, MHD and plasma simulations, and image processing. While there has been a lot of interest from mathematicians, physicists and engineers in DGM, only scattered information is available and there has been no prior effort in organizing and publishing the existing volume of knowledge on this subject. In May 24-26, 1999 we organized in Newport (Rhode Island, USA), the first international symposium on DGM with equal emphasis on the theory, numerical implementation, and applications. Eighteen invited speakers, lead ers in the field, and thirty-two contributors presented various aspects and addressed open issues on DGM. In this volume we include forty-nine papers presented in the Symposium as well as a survey paper written by the organiz ers. All papers were peer-reviewed. A summary of these papers is included in the survey paper, which also provides a historical perspective of the evolution of DGM and its relation to other numerical methods. We hope this volume will become a major reference in this topic. It is intended for students and researchers who work in theory and application of numerical solution of convection dominated partial differential equations. The papers were written with the assumption that the reader has some knowledge of classical finite elements and finite volume methods.

These proceedings contain a selection of refereed contributions as a source of reference for all those interested in the state of the art in computational fluid dynamics. The conference brings together physicists, mathematicians and engineers to review and share recent advances in the field.

This book highlights recent research advances in the area of turbulent flows from both industry and academia for applications in the area of Aerospace and Mechanical engineering. Contributions include modeling, simulations and experiments meant for researchers, professionals and students in the area.

An Introduction to Computational Fluid Dynamics The Finite Volume Method, 2/e

Turbulence Modeling for CFD: CD-ROM

Proceedings of the First International Conference on Computational Fluid Dynamics, ICCFD, Kyoto, Japan, 10–14 July 2000

Implementation and Validation of a Modified Non-equilibrium Wilcox K Omega Turbulence Model in Subsonic and Transonic Flow Regimes

Closure Strategies for Turbulent and Transitional Flows

This Third Edition, in response to the enthusiastic reception given by academia and students to the previous edition, offers a cohesive presentation of all aspects of theoretical computer science, namely automata, formal languages, computability, and complexity. Besides, it includes coverage of mathematical preliminaries. NEW TO THIS EDITION • Expanded sections on pigeonhole principle and the principle of induction (both in Chapter 2) • A rigorous proof of Kleene's theorem (Chapter 5) • Major changes in the chapter on Turing machines (TMs) – A new section on high-level description of TMs – Techniques for the construction of TMs – Multitape TM and nondeterministic TM • A new chapter (Chapter 10) on decidability and recursively enumerable languages • A new chapter (Chapter 12) on complexity theory and NP-complete problems • A section on quantum computation in Chapter 12. • KEY FEATURES • Objective-type questions in each chapter—with answers provided at the end of the book. • Eighty-three additional solved examples—added as Supplementary Examples in each chapter. • Detailed solutions at the end of the book to chapter-end exercises. The book is designed to meet the needs of the undergraduate and postgraduate students of computer science and engineering as well as those of the students offering courses in computer applications.

This book covers a wide variety of topics related to advancements in different stages of mass transfer modelling processes. Its purpose is to create a platform for the exchange of recent observations, experiences, and achievements. It is recommended for those in the chemical, biotechnological, pharmaceutical, and nanotechnology industries as well as for students of natural sciences, technical, environmental and employees in companies which manufacture machines for the above-mentioned industries. This work can also be a useful source for researchers and engineers dealing with mass transfer and related issues.

Computational Fluid Mechanics and Heat Transfer, Fourth Edition is a fully updated version of the classic text on finite-difference and finite-volume computational methods. Divided into two parts, the text covers essential concepts, and then moves on to fluids equations in the second part. Designed as a valuable resource for practitioners and students, new examples and homework problems have been added to further enhance the student's understanding of the fundamentals and applications. Provides a thoroughly updated presentation of CFD and computational heat transfer Covers more material than other texts, organized for classroom instruction and self-study Presents a range of flow computation strategies and extensive computational heat transfer coverage Includes more extensive coverage of computational heat transfer methods Features a full Solutions Manual and Figure Slides for classroom projection Written as an introductory text for advanced undergraduates and first-year graduate students, the new edition provides the background necessary for solving complex problems in fluid mechanics and heat transfer.

Modeling and Simulation of Turbulent Mixing and Reaction

Applied Computational Fluid Dynamics

Computational Fluid Dynamics 2008

Modelling and Simulation of Turbulent Heat Transfer

Principles Of Fluid Mechanics And Fluid Machines (second Edition)