

## Chapter 6 • Viscous Flow in Ducts

**P6.1** An engineer claims that flow of SAE 30W oil, at 20°C, through a 5-cm-diameter smooth pipe at 1 million N/h, is laminar. Do you agree? A million newtons is a lot, so this sounds like an awfully high flow rate.

**Solution:** For SAE 30W oil at 20°C (Table A.3), take  $\rho = 891 \text{ kg/m}^3$  and  $\mu = 0.29 \text{ kg/m-s}$ . Convert the weight flow rate to volume flow rate in SI units:

$$Q = \frac{\dot{w}}{\rho g} = \frac{(1\text{E}6 \text{ N/h})(1/3600 \text{ h/s})}{(891 \text{ kg/m}^3)(9.81 \text{ m/s}^2)} = 0.0318 \frac{\text{m}^3}{\text{s}} = \frac{\pi}{4} (0.05 \text{ m})^2 V, \text{ solve } V = 16.2 \frac{\text{m}}{\text{s}}$$

$$\text{Calculate } Re_D = \frac{\rho V D}{\mu} = \frac{(891 \text{ kg/m}^3)(16.2 \text{ m/s})(0.05 \text{ m})}{0.29 \text{ kg/m-s}} = \mathbf{2500} \text{ (transitional)}$$

This is not high, but **not** laminar. *Ans.* With careful inlet design, low disturbances, and a very smooth wall, it might still be laminar, but **No**, this is *transitional*, not definitely laminar.

**P6.2** The present pumping rate of North Slope crude oil through the Alaska Pipeline (see the chapter-opener photo) is about 600,000 barrels per day (1 barrel = 42 U.S. gallons). What would be the maximum rate if the flow were constrained to be *laminar*? Assume that Alaskan crude oil fits Fig. A.1 of the Appendix at 60°C.

**Solution:** From Fig. A.1 for crude at 60°C,  $\rho = 0.86(1000) = 860 \text{ kg/m}^3$  and  $\mu = 0.0040 \text{ kg/m-s}$ . From Eq. (6.2), the maximum laminar Reynolds number is about 2300. Convert the pipe diameter from 48 inches to 1.22 m. Solve for velocity:

$$Re_D = 2300 = \frac{\rho V D}{\mu} = \frac{(860 \text{ kg/m}^3) V (1.22 \text{ m})}{0.0040 \text{ kg/m-s}}; \text{ Solve for } V = 0.00877 \frac{\text{m}}{\text{s}}$$

$$Q = VA = (0.00877 \text{ m/s})(\pi/4)(1.22 \text{ m})^2 = 0.01025 \text{ m}^3/\text{s} \times 3600 \times 24 = \\ = 886 \text{ m}^3/\text{day} \approx \mathbf{5600} \text{ barrels/day } \textit{Ans.}$$

# Introduction Fluid Mechanics 7th Edition Solution Manual

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**A Brief Introduction to Fluid Mechanics** Donald F. Young, Bruce R. Munson, Theodore H. Okiishi, Wade W. Huebsch, 2010-12-21 A Brief Introduction to Fluid Mechanics 5th Edition is designed to cover the standard topics in a basic fluid mechanics course in a streamlined manner that meets the learning needs of today's student better than the dense encyclopedic manner of traditional texts This approach helps students connect the math and theory to the physical world and practical applications and apply these connections to solving problems The text lucidly presents basic analysis techniques and addresses practical concerns and applications such as pipe flow open channel flow flow measurement and drag and lift It offers a strong visual approach with photos illustrations and videos included in the text examples and homework problems to emphasize the practical application of fluid mechanics principles Fundamentals of Fluid Mechanics 7E Binder Ready Version with Student Solutions Manual/Study Guide Bruce R. Munson, 2012-05-07 **GAS DYNAMICS, Seventh Edition** RATHAKRISHNAN, E., 2020-07-01 This revised and updated seventh edition continues to provide the most accessible and readable approach to the study of all the vital topics and issues associated with gas dynamic processes At every stage the physics governing the process its applications and limitations are discussed in detail With a strong emphasis on the basic concepts and problem solving skills this text is suitable for a course on Gas Dynamics Compressible Flows High speed Aerodynamics at both undergraduate and postgraduate levels in aerospace engineering mechanical engineering chemical engineering and applied physics The elegant and concise style of the book along with illustrations and worked out examples makes it eminently suitable for self study by students and also for scientists and engineers working in the field of gas dynamics in industries and research laboratories The computer program to calculate the coordinates of contoured nozzle with the method of characteristics has been given in C language The program listing along with a sample output is given in the Appendix NEW TO THE EDITION A new chapter on the Power of Compressible Bernoulli Equation Extra chapter end examples in Chapter 5 Additional exercise problems in Chapters 5 6 7 and 8 KEY FEATURES Concise coverage of the thermodynamic concepts to serve as a revision of the background material Introduction to measurements in compressible flows and optical flow visualization techniques Introduction to rarefied gas dynamics and high temperature gas dynamics Solutions Manual for instructors containing the complete worked out solutions to chapter end problems In depth presentation of potential equations for compressible flows similarity rule and two dimensional compressible flows Logical and systematic treatment of fundamental aspects of gas dynamics waves in the supersonic regime and gas dynamic processes TARGET AUDIENCE BE B Tech Mechanical Engineering Aeronautical Engineering ME M Tech Thermal Engineering Aeronautical Engineering Fluid Mechanics and Thermodynamics of Turbomachinery Dan Zhao, S. Larry Dixon, Cesare Hall, 2025-05-05 Fluid Mechanics and Thermodynamics of Turbomachinery Eighth Edition is the leading turbomachinery book with its balanced coverage of theory and application Starting with background principles in fluid mechanics and

thermodynamics this updated edition goes on to discuss axial flow turbines and compressors centrifugal pumps fans and compressors and radial flow gas turbines hydraulic turbines and wind turbines Used as a core text in senior undergraduate and graduate level courses this book will also appeal to professional engineers in the aerospace global power oil gas and other industries who are involved in the design and operation of turbomachines Provides the most comprehensive coverage of turbomachinery fundamentals of any text in the field Examines through the laws of fluid mechanics and thermodynamics the means by which energy transfer is achieved in the chief types of turbomachines together with the differing behavior of individual types in operation Discusses important aspects concerning the criteria of blade selection and blade manufacture control methods for regulating power output and rotor speed and performance testing Includes coverage of public and environmental issues which are becoming increasingly important as they can affect the development of wind turbines Online teaching ancillaries include a fully updated solutions manual and image bank

**Engineering Fluid Mechanics** Donald F. Elger, Barbara A. LeBret, Clayton T. Crowe, John A. Roberson, 2020-07-08 Engineering Fluid Mechanics guides students from theory to application emphasizing critical thinking problem solving estimation and other vital engineering skills Clear accessible writing puts the focus on essential concepts while abundant illustrations charts diagrams and examples illustrate complex topics and highlight the physical reality of fluid dynamics applications Over 1 000 chapter problems provide the deliberate practice with feedback that leads to material mastery and discussion of real world applications provides a frame of reference that enhances student comprehension The study of fluid mechanics pulls from chemistry physics statics and calculus to describe the behavior of liquid matter as a strong foundation in these concepts is essential across a variety of engineering fields this text likewise pulls from civil engineering mechanical engineering chemical engineering and more to provide a broadly relevant immediately practicable knowledge base Written by a team of educators who are also practicing engineers this book merges effective pedagogy with professional perspective to help today s students become tomorrow s skillful engineers

*Aerodynamics for Engineering Students* Steven H. Collicott, Daniel T. Valentine, E. L. Houghton, P. W. Carpenter, 2016-08-12 Aerodynamics for Engineering Students Seventh Edition is one of the world s leading course texts on aerodynamics It provides concise explanations of basic concepts combined with an excellent introduction to aerodynamic theory This updated edition has been revised with improved pedagogy and reorganized content to facilitate student learning and includes new or expanded coverage in several important areas such as hypersonic flow UAV s and computational fluid dynamics Provides contemporary applications and examples that help students see the link between everyday physical examples of aerodynamics and the application of aerodynamic principles to aerodynamic design Contains MATLAB based computational exercises throughout giving students practice in using industry standard computational tools Includes examples in SI and Imperial units reflecting the fact that the aerospace industry uses both systems of units Improved pedagogy including more examples and end of chapter problems and additional and updated MATLAB codes

**Fundamentals of Fluid Mechanics** Bruce R. Munson, Donald F. Young, Theodore H. Okiishi, 1998 This students solutions manual accompanies the main text Each concept of fluid mechanics is considered in the book in simple circumstances before more complicated features are introduced The problems are presented in a mixture of SI and US standard units

**The Finite Element Method in Heat Transfer and Fluid Dynamics, Third Edition** J. N. Reddy, D.K. Gartling, 2010-04-06 As Computational Fluid Dynamics CFD and Computational Heat Transfer CHT evolve and become increasingly important in standard engineering design and analysis practice users require a solid understanding of mechanics and numerical methods to make optimal use of available software The Finite Element Method in Heat Transfer and Fluid Dynamics Third Edition illustrates what a user must know to ensure the optimal application of computational procedures particularly the Finite Element Method FEM to important problems associated with heat conduction incompressible viscous flows and convection heat transfer This book follows the tradition of the bestselling previous editions noted for their concise explanation and powerful presentation of useful methodology tailored for use in simulating CFD and CHT The authors update research developments while retaining the previous editions key material and popular style in regard to text organization equation numbering references and symbols This updated third edition features new or extended coverage of Coupled problems and parallel processing Mathematical preliminaries and low speed compressible flows Mode superposition methods and a more detailed account of radiation solution methods Variational multi scale methods VMM and least squares finite element models LSFEM Application of the finite element method to non isothermal flows Formulation of low speed compressible flows With its presentation of realistic applied examples of FEM in thermal and fluid design analysis this proven masterwork is an invaluable tool for mastering basic methodology competently using existing simulation software and developing simpler special purpose computer codes It remains one of the very best resources for understanding numerical methods used in the study of fluid mechanics and heat transfer phenomena

**Engineering Education**, 1985

**Fluid Mechanics with Civil Engineering Applications, Eleventh Edition** E. John Finnemore, Ed Maurer, 2023-12-08 A complete guide to fluid mechanics for engineers fully updated for current standards This thoroughly revised classic guide clearly explains the principles and applications of fluid mechanics and hydraulics in a straightforward manner without using complicated mathematics While aimed at undergraduate students practicing engineers will also benefit from the hands on information covered You will explore fluid mechanics fundamentals pipe and open channel flow unsteady flow and much more Written by a pair of experienced engineering educators Fluid Mechanics with Civil Engineering Applications Eleventh Edition focuses on reducing and streamlining content while retaining its traditional approach to teaching fundamental concepts by solving engineering problems This overhauled edition features new practical sample problems and exercises and incorporates digital resources while removing some more advanced topics less essential to civil engineering Contains new and extensively updated content to meet current standards Incorporates new examples and problems Includes a new online

problem and solutions manual as well as additional resources for students and instructors

**Fundamentals of Momentum, Heat and Mass Transfer** James P. Welty, 2019-03-18 The Aeronautical Journal, 1999 Subject Guide to Books in Print, 2001

**Introduction to Fluid Mechanics** James E. A. John, William L. Haberman, 1988 *Fundamentals of Momentum, Heat, and Mass Transfer* James Welty, Gregory L. Rorrer, David G. Foster, 2020-06-23

The field's essential standard for more than three decades *Fundamentals of Momentum Heat and Mass Transfer* offers a systematic introduction to transport phenomena and rate processes Thorough coverage of central principles helps students build a foundational knowledge base while developing vital analysis and problem solving skills Momentum heat and mass transfer are introduced sequentially for clarity of concept and logical organization of processes while examples of modern applications illustrate real world practices and strengthen student comprehension Designed to keep the focus on concept over content this text uses accessible language and efficient pedagogy to streamline student mastery and facilitate further exploration Abundant examples practice problems and illustrations reinforce basic principles while extensive tables simplify comparisons of the various states of matter Detailed coverage of topics including dimensional analysis viscous flow conduction convection and molecular diffusion provide broadly relevant guidance for undergraduates at the sophomore or junior level with special significance to students of chemical mechanical environmental and biochemical engineering

**Introduction to Microwave Imaging** Natalia K. Nikolova, 2017-07-13 With this self contained introductory text readers will easily understand the fundamentals of microwave and radar image generation Written with the complete novice in mind and including an easy to follow introduction to electromagnetic scattering theory it covers key topics such as forward models of scattering for interpreting S parameter and time dependent voltage data S parameters and their analytical sensitivity formulae basic methods for real time image reconstruction using frequency sweep and pulsed radar signals and metrics for evaluating system performance Numerous application examples and practical tutorial exercises provided throughout allow quick understanding of key concepts and sample MATLAB codes implementing key reconstruction algorithms accompany the book online This one stop resource is ideal for graduate students taking introductory courses in microwave imaging as well as researchers and industry professionals wanting to learn the fundamentals of the field

*Computer Modeling Applications for Environmental Engineers* Isam Mohammed Abdel-Magid Ahmed, Mohammed Isam Mohammed Abdel-Magid, 2017-07-06

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