(a)
$$BF = \rho V \omega^2 r = \left(62.3 \frac{\text{lbm}}{\text{ft}^3}\right) \left(0.01 \text{in}^3 \left(\frac{2\pi \cdot 1000}{\text{min}} \cdot \frac{\text{min}}{60 \text{ s}}\right)^2 \left(15 \text{ in}\right) \frac{\text{lbf s}^2}{32.17 \text{ lbm ft}} \cdot \left(\frac{\text{ft}^2}{144 \text{ in}^2}\right)^2$$

= 0.153 lbf = 0.683 N

(b) This points toward the axis of rotation.

2.73 See the sketch at the right. Work in gage pressure.

$$P_{1} = 0$$

$$P_{2} = P_{1}\rho g(h_{2} - h_{1})$$

$$P_{3} = P_{2} + \frac{\rho e \sigma^{2}}{2}(r_{3}^{2} - r_{2}^{2})$$

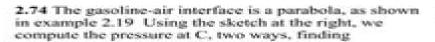
$$P_{4} = P_{3} + \rho g(h_{4} - h_{3})$$



$$P_4 = \rho \left[g(h_4 - h_1) + \frac{\omega^2}{2} (r_1^2 - r_2^2) \right]$$

$$\omega = \frac{2\pi \cdot 10}{60 \text{ s}} = 1.0472 \frac{1}{\text{s}}$$

$$P_4 = 62.3 \frac{\text{lbm}}{\text{ft}^3} \left[32.2 \frac{\text{ft}}{\text{s}^2} \cdot 4 \text{ ft} + \frac{1}{2} \cdot \left(\frac{1.0472}{\text{s}} \right)^2 \cdot \left((22 \text{ ft})^2 - (24 \text{ ft})^2 \right) \right] \cdot \frac{\text{lbf s}^2}{32.2 \text{ lbm ft}} \cdot \frac{\text{ft}^2}{144 \text{ in}^2}$$
$$= 62.3 \cdot \left[128.8 - 50.44 \right] \frac{1}{32.2 \cdot 144} = 1.053 \text{ psig} = 7.26 \text{ kPa gauge}$$



By path DBC

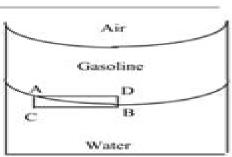
$$P_{C} = P_{D} + \rho_{\text{gaustice}} g \Delta z + \rho_{\text{water}} \frac{6\delta^{2}}{2} (\Delta r)^{2}$$

By path DAC

$$P_C = P_D + \rho_{gaustine} \frac{\omega^2}{2} (\Delta r)^2 + \rho_{water} g \Delta z$$

Subtracting the second from the first

$$0 = \left(\rho_{water} - \rho_{gaustine}\right) \frac{\alpha s^2}{2} (\Delta r)^2 - \left(\rho_{water} - \rho_{gaustine}\right) g \Delta z$$



Fluid Mechanics For Chemical Engineers 3rd Edition

Donald C. Rennels, Hobart M. Hudson

Fluid Mechanics For Chemical Engineers 3rd Edition:

Fluid Mechanics for Chemical Engineers Noel De Nevers, 2011 Fluid Mechanics for Chemical Engineers with **Engineering Subscription Card** Noel De Nevers, 2004-02 Fluid Mechanics for Chemical Engineers third edition retains the characteristics that made this introductory text a success in prior editions It is still a book that emphasizes material and energy balances and maintains a practical orientation throughout No more math is included than is required to understand the concepts presented To meet the demands of today's market the author has included many problems suitable for solution by computer Three brand new chapters are included Chapter 15 on Two and Three Dimensional Fluid Mechanics Chapter 19 on Mixing and Chapter 20 on Computational Fluid Dynamics CFD **Fluid Mechanics for Chemical Engineers** James O. Wilkes, 2017-07-20 The Chemical Engineer's Practical Guide to Fluid Mechanics Now Includes COMSOL Multiphysics 5 Since most chemical processing applications are conducted either partially or totally in the fluid phase chemical engineers need mastery of fluid mechanics Such knowledge is especially valuable in the biochemical chemical energy fermentation materials mining petroleum pharmaceuticals polymer and waste processing industries Fluid Mechanics for Chemical Engineers with Microfluidics CFD and COMSOL Multiphysics 5 Third Edition systematically introduces fluid mechanics from the perspective of the chemical engineer who must understand actual physical behavior and solve real world problems Building on the book that earned Choice Magazine's Outstanding Academic Title award this edition also gives a comprehensive introduction to the popular COMSOL Multiphysics 5 software This third edition contains extensive coverage of both microfluidics and computational fluid dynamics systematically demonstrating CFD through detailed examples using COMSOL Multiphysics 5 and ANSYS Fluent The chapter on turbulence now presents valuable CFD techniques to investigate practical situations such as turbulent mixing and recirculating flows Part I offers a clear succinct easy to follow introduction to macroscopic fluid mechanics including physical properties hydrostatics basic rate laws and fundamental principles of flow through equipment Part II turns to microscopic fluid mechanics Differential equations of fluid mechanics Viscous flow problems some including polymer processing Laplace's equation irrotational and porous media flows Nearly unidirectional flows from boundary layers to lubrication calendering and thin film applications Turbulent flows showing how the k method extends conventional mixing length theory Bubble motion two phase flow and fluidization Non Newtonian fluids including inelastic and viscoelastic fluids Microfluidics and electrokinetic flow effects including electroosmosis electrophoresis streaming potentials and electroosmotic switching Computational fluid mechanics with ANSYS Fluent and COMSOL Multiphysics Nearly 100 completely worked practical examples include 12 new COMSOL 5 examples boundary layer flow non Newtonian flow jet flow die flow lubrication momentum diffusion turbulent flow and others More than 300 end of chapter problems of varying complexity are presented including several from University of Cambridge exams The author covers all material needed for the fluid mechanics portion of the professional engineer's exam The author's website fmche engin umich edu provides

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Multiphase Particulate Systems in Turbulent Flows Fluid Liquid and Solid Liquid Dispersions provides methods necessary to analyze complex particulate systems and related phenomena including physical chemical and mathematical description of fundamental processes influencing crystal size and shape suspension rheology interfacial area of drops and bubbles in extractors and bubble columns Examples of mathematical model formulation for different processes taking place in such systems is shown Discussing connections between turbulent mixing mechanisms and precipitation it discusses influence of fine scale structure of turbulence including its intermittent character on breakage of drops bubbles cells plant cell aggregates An important aspect of the mathematical modeling presented in the book is multi fractal taking into account the influence of internal intermittency on different phenomena Key Features Provides detailed descriptions of dispersion processes in turbulent flow interactions between dispersed entities and continuous phase in a single volume Includes simulation models and validation experiments for liquid liquid gas liquid and solid liquid dispersions in turbulent flows Helps reader learn formulation of mathematical models of breakage or aggregation processes using multifractal theory Explains how to solve different forms of population balance equations Presents a combination of theoretical and engineering approaches to particulate systems along with discussion of related diversity with exercises and case studies Diffusion E. L. Cussler, 1997-02-28 Clear and complete description of diffusion in fluids for undergraduate students in chemical Process Control B. Wayne Bequette, 2003 Master process control hands on through practical examples and engineering MATLAB R simulations This is the first complete introduction to process control that fully integrates software tools enabling professionals and students to master critical techniques hands on through computer simulations based on the popular MATLAB environment Process Control Modeling Design and Simulation teaches the field s most important techniques behaviors and control problems through practical examples supplemented by extensive exercises with detailed derivations relevant software files and additional techniques available on a companion Web site Coverage includes Fundamentals of process control and instrumentation including objectives variables and block diagrams Methodologies for developing dynamic models of chemical processes Dynamic behavior of linear systems state space models transfer function based models and more Feedback control proportional integral and derivative PID controllers and closed loop stability analysis Frequency response analysis techniques for evaluating the robustness of control systems Improving control loop performance internal model control IMC automatic tuning gain scheduling and enhancements to improve disturbance rejection Split range selective and override strategies for switching among inputs or outputs Control loop interactions and multivariable controllers An introduction to model predictive control MPC Bequette walks step by step through the development of control instrumentation diagrams for an entire chemical process reviewing common control strategies for individual unit operations then discussing strategies for integrated systems The book also includes 16 learning modules demonstrating how to use MATLAB and SIMULINK to solve several key control problems ranging from robustness analyses to biochemical reactors

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