

GLOBAL
EDITION



Fluid Mechanics

Second Edition in SI Units

R. C. Hibbeler



สำนักหอสมุด มหาวิทยาลัยเชียงใหม่

616705828
0 125 77595
1 2268606X

FLUID MECHANICS

SECOND EDITION IN SI UNITS

R. C. HIBBELER

SI Conversion by
Kai Beng Yap



สำนักหอสมุดมหาวิทยาลัยเชียงใหม่
CHIANG MAI UNIVERSITY LIBRARY

 **Pearson**

CONTENTS

1 Fundamental Concepts 19



Chapter Objectives 19

- 1.1 Introduction 19
- 1.2 Characteristics of Matter 21
- 1.3 The International System of Units 22
- 1.4 Calculations 25
- 1.5 Problem Solving 27
- 1.6 Some Basic Fluid Properties 29
- 1.7 Viscosity 34
- 1.8 Viscosity Measurement 39
- 1.9 Vapor Pressure 43
- 1.10 Surface Tension and Capillarity 44

3 Kinematics of Fluid Motion 153



Chapter Objectives 153

- 3.1 Types of Fluid Flow 153
- 3.2 Graphical Descriptions of Fluid Flow 157
- 3.3 Fluid Flow Descriptions 161
- 3.4 Fluid Acceleration 168
- 3.5 Streamline Coordinates 175

2 Fluid Statics 61



Chapter Objectives 61

- 2.1 Pressure 61
- 2.2 Absolute and Gage Pressure 64
- 2.3 Static Pressure Variation 66
- 2.4 Pressure Variation for Incompressible Fluids 67
- 2.5 Pressure Variation for Compressible Fluids 69
- 2.6 Measurement of Static Pressure 72
- 2.7 Hydrostatic Force on a Plane Surface—Formula Method 80
- 2.8 Hydrostatic Force on a Plane Surface—Geometrical Method 86
- 2.9 Hydrostatic Force on a Plane Surface—Integration Method 91
- 2.10 Hydrostatic Force on an Inclined Plane or Curved Surface Determined by Projection 94
- 2.11 Buoyancy 101
- 2.12 Stability 104
- 2.13 Constant Translational Acceleration of a Liquid 107
- 2.14 Steady Rotation of a Liquid 112

4 Conservation of Mass 189



Chapter Objectives 189

- 4.1 Volumetric Flow, Mass Flow, and Average Velocity 189
- 4.2 Finite Control Volumes 194
- 4.3 The Reynolds Transport Theorem 196
- 4.4 Conservation of Mass 200

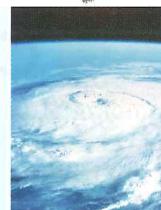
5

**Work and Energy
of Moving Fluids 231**

Chapter Objectives 231

- 5.1 Euler's Equations of Motion 231
- 5.2 The Bernoulli Equation 235
- 5.3 Applications of the Bernoulli Equation 238
- 5.4 Energy and Hydraulic Grade Lines 251
- 5.5 The Energy Equation 260

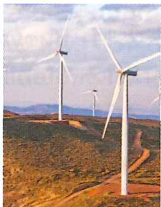
7

**Differential Fluid
Flow 359**

Chapter Objectives 359

- 7.1 Differential Analysis 359
- 7.2 Kinematics of Differential Fluid Elements 360
- 7.3 Circulation and Vorticity 364
- 7.4 Conservation of Mass 369
- 7.5 Equations of Motion for a Fluid Particle 371
- 7.6 The Euler and Bernoulli Equations 373
- 7.7 Potential Flow Hydrodynamics 377
- 7.8 The Stream Function 377
- 7.9 The Potential Function 383
- 7.10 Basic Two-Dimensional Flows 387
- 7.11 Superposition of Flows 396
- 7.12 The Navier–Stokes Equations 409
- 7.13 Computational Fluid Dynamics 414

6

Fluid Momentum 301

Chapter Objectives 301

- 6.1 The Linear Momentum Equation 301
- 6.2 Applications to Bodies at Rest 304
- 6.3 Applications to Bodies Having Constant Velocity 313
- 6.4 The Angular Momentum Equation 318
- 6.5 Propellers and Wind Turbines 326
- 6.6 Applications for Control Volumes Having Accelerated Motion 331
- 6.7 Turbojets and Turbofans 332
- 6.8 Rockets 333

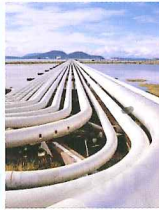
8

**Dimensional
Analysis and
Similitude 435**

Chapter Objectives 435

- 8.1 Dimensional Analysis 435
- 8.2 Important Dimensionless Numbers 438
- 8.3 The Buckingham Pi Theorem 441
- 8.4 Some General Considerations Related to Dimensional Analysis 450
- 8.5 Similitude 451

9

Viscous Flow within Enclosed Conduits 475

Chapter Objectives 475

- 9.1 Steady Laminar Flow between Parallel Plates 475
- 9.2 Navier–Stokes Solution for Steady Laminar Flow between Parallel Plates 481
- 9.3 Steady Laminar Flow within a Smooth Pipe 486
- 9.4 Navier–Stokes Solution for Steady Laminar Flow within a Smooth Pipe 490
- 9.5 The Reynolds Number 492
- 9.6 Fully Developed Flow from an Entrance 497
- 9.7 Laminar and Turbulent Shear Stress within a Smooth Pipe 499
- 9.8 Steady Turbulent Flow within a Smooth Pipe 502

10

Analysis and Design for Pipe Flow 521

Chapter Objectives 521

- 10.1 Resistance to Flow in Rough Pipes 521
- 10.2 Losses Occurring from Pipe Fittings and Transitions 535
- 10.3 Single-Pipeline Flow 541
- 10.4 Pipe Systems 548
- 10.5 Flow Measurement 554

11

Viscous Flow over External Surfaces 575

Chapter Objectives 575

- 11.1 The Concept of the Boundary Layer 575
- 11.2 Laminar Boundary Layers 581
- 11.3 The Momentum Integral Equation 590
- 11.4 Turbulent Boundary Layers 594
- 11.5 Laminar and Turbulent Boundary Layers 596
- 11.6 Drag and Lift 602
- 11.7 Pressure Gradient Effects 604
- 11.8 The Drag Coefficient 609
- 11.9 Drag Coefficients for Bodies Having Various Shapes 613
- 11.10 Methods for Reducing Drag 620
- 11.11 Lift and Drag on an Airfoil 624

12

Open-Channel Flow 655

Chapter Objectives 655

- 12.1 Types of Flow in Open Channels 655
- 12.2 Open-Channel Flow Classifications 657
- 12.3 Specific Energy 658
- 12.4 Open-Channel Flow over a Rise or Bump 666
- 12.5 Open-Channel Flow under a Sluice Gate 670
- 12.6 Steady Uniform Channel Flow 674
- 12.7 Gradually Varied Flow 681
- 12.8 The Hydraulic Jump 688
- 12.9 Weirs 693

13

Compressible Flow 715

Chapter Objectives 715

- 13.1 Thermodynamic Concepts 715
- 13.2 Wave Propagation through a Compressible Fluid 724
- 13.3 Types of Compressible Flow 727
- 13.4 Stagnation Properties 731
- 13.5 Isentropic Flow through a Variable Area 738
- 13.6 Isentropic Flow through Converging and Diverging Nozzles 743
- 13.7 The Effect of Friction on Compressible Flow 752
- 13.8 The Effect of Heat Transfer on Compressible Flow 762
- 13.9 Normal Shock Waves 768
- 13.10 Shock Waves in Nozzles 771
- 13.11 Oblique Shock Waves 776
- 13.12 Compression and Expansion Waves 781
- 13.13 Compressible Flow Measurement 786

14

Turbomachines 807

Chapter Objectives 807

- 14.1 Types of Turbomachines 807
- 14.2 Axial-Flow Pumps 808
- 14.3 Radial-Flow Pumps 815
- 14.4 Ideal Performance for Pumps 818
- 14.5 Turbines 824
- 14.6 Pump Performance 831
- 14.7 Cavitation and the Net Positive Suction Head 834
- 14.8 Pump Selection Related to the Flow System 836
- 14.9 Turbomachine Similitude 838

Appendix

- A Physical Properties of Fluids 856
- B Compressible Properties of a Gas ($k = 1.4$) 859

Fundamental Solutions 870**Answers to Selected Problems 886****Index 899**