

Contents

Tables *xi*

Preface *xiii*

To the Student *xvii*

1	Introduction	<i>1</i>
1.1	The World of Fluid Mechanics	<i>1</i>
1.2	The Physics of Fluids	<i>10</i>
1.3	Dimensions and Units of Measurement	<i>24</i>
1.4	Vector Algebra and Calculus	<i>29</i>
1.5	Problems	<i>36</i>
	Bibliography	<i>38</i>
2	Fluid Statics	<i>39</i>
2.1	Forces on a Fluid Particle	<i>39</i>
2.2	Stress in a Fluid	<i>40</i>
2.3	Pressure in a Static Fluid	<i>41</i>
2.4	Pressure Forces on Solid Surfaces	<i>52</i>
2.5	Pressure Forces on Bodies Immersed in Fluids	<i>60</i>
2.6	Stratified Fluids	<i>68</i>
2.7	Surface Tension and Capillarity	<i>75</i>

	2.8	Hydraulic Force Transmission	77
	2.9	Problems	79
		Bibliography	88
3		Conservation of Mass	89
	3.1	Kinematics of Fluid Flow	89
	3.2	Control Volumes and Surfaces	97
	3.3	Conservation of Mass	100
	3.4	Conservation of Chemical Species	107
	3.5	Two-Phase Flow	110
	3.6	Measuring Volume and Volume Flow Rate	111
	3.7	Problems	111
		Bibliography	125
4		Inviscid Flow	127
	4.1	Criterion for Inviscid Flow	127
	4.2	Acceleration of a Fluid Particle	128
	4.3	Euler's Equation	130
	4.4	Bernoulli's Equation	133
	4.5	Euler's Equation in Streamline Coordinates	150
	4.6	Inviscid Flow in Noninertial Reference Frames	152
	4.7	Special Flows	160
	4.8	Problems	163
		Bibliography	184
5		Conservation of Momentum	185
	5.1	Introduction	185
	5.2	Reynolds' Transport Theorem	186
	5.3	Linear Momentum	189
	5.4	Applications of the Linear Momentum Theorem	197
	5.5	Angular Momentum	219

- 5.7 Problems 232
- Bibliography 263
- 6 Laminar Viscous Flow 265**
 - 6.1 Introduction 265
 - 6.2 The Viscous Stress 266
 - 6.3 The Viscous Force 269
 - 6.4 The Navier-Stokes Equation of Motion 271
 - 6.5 Applications of the Navier-Stokes Equation 275
 - 6.6 Laminar Boundary Layers 311
 - 6.7 Problems 324
 - Bibliography 352
- 7 Turbulent Viscous Flow 353**
 - 7.1 Introduction 353
 - 7.2 Characteristics of Turbulent Flow 353
 - 7.3 Turbulent Skin Friction and Drag 361
 - 7.4 Simple Models of Turbulent Mean Flow 368
 - 7.5 Problems 374
 - Bibliography 376
- 8 Conservation of Energy 377**
 - 8.1 Introduction 377
 - 8.2 Incompressible Viscous Flow 378
 - 8.3 The First Law of Thermodynamics 386
 - 8.4 The Second Law of Thermodynamics 394
 - 8.5 Derivation of the Differential Form of the First Law 397
 - 8.6 Problems 399
 - Bibliography 400
- 9 Flow in Fluid Systems 401**
 - 9.1 Introduction 401

9.3	Head Changes in Systems with Pumps and Turbines	415
9.4	Complex Networks	420
9.5	Problems	428
	Bibliography	439
10	Dimensional Analysis and Modeling	441
10.1	Introduction	441
10.2	Dimensional Analysis	442
10.3	Modeling	456
10.4	Drag	473
10.5	Lift	478
10.6	Problems	482
	Bibliography	493
11	Irrotational Flow	495
11.1	Introduction	495
11.2	Vorticity	496
11.3	The Stream Function for Incompressible Flow	502
11.4	Plane Irrotational Flows	506
11.5	Axisymmetric Irrotational Flows	532
11.6	Flow over Airfoils and Wings	540
11.7	Numerical Solutions	544
11.8	Potential Flow	547
11.9	Problems	548
	Bibliography	551
12	Compressible Flow	553
12.1	Introduction	553
12.2	The Speed of Sound	555
12.3	Steady Isentropic Flow	560
12.4	Shock Waves	570

12.6 Plane Supersonic Flow	580
12.7 One-Dimensional Unsteady Flow	590
12.8 Problems	596
Bibliography	598

Index	599
--------------	------------