

Contents

<i>Preface</i>	page ix
<i>Acknowledgments</i>	xi
1 Mass Conservation and the Continuity Equation	1
1.1 Conservation in Fluid Mechanics	1
1.2 Conservation of Mass in One Dimension	4
1.3 The Continuity Equation	8
1.4 Discussion of the Continuity Equation	16
Problems	30
2 The Material Derivative: The First Step to the Navier–Stokes Equations	32
2.1 Lagrangian and Eulerian Descriptions	33
2.2 The Advection and Inviscid Burgers’ Equation	40
2.3 The Material Derivative and the Continuity Equation	51
2.4 The Material Derivative in the Navier–Stokes Equations	55
2.5 Take Home Points	57
Problems	58
3 Force Balance, the Stress Tensor, and the Navier–Stokes Equations	60
3.1 Forces on a Fluid and the Stress Tensor	60
3.2 General Force Balance: Cauchy’s First Law of Motion	69
3.3 The Form of the Stress Tensor	71
3.4 The Navier–Stokes Equations ... Finally	80
3.5 Incompressible Flow	94
Problems	100

4	The Navier–Stokes Equations: Another Approach	102
4.1	Eulerian Approach to the Navier–Stokes Equations	102
4.2	Take a Breath: Let’s Review So Far	108
4.3	Incompressible Equations in 2D Cartesian Coordinates	112
4.4	Boundary Conditions	114
4.5	Examples	116
	Problems	122
5	The Energy Equation and a Discussion on Diffusion and Advection	124
5.1	Conservation of Energy	124
5.2	A Very Common Form of the Energy Equation	140
5.3	Initial Discussion of the Energy Equation	147
5.4	Full Governing Equations of Fluid Motion	153
5.5	Diffusion	155
5.6	Convection–Diffusion Equation: Combined Advection and Diffusion	162
5.7	The Boundary Layer	165
5.8	Boundary Conditions for the Energy Equation	173
5.9	Examples	174
	Problems	180
6	Nondimensionalization and Scaling	182
6.1	The Idea Behind Nondimensionalization	182
6.2	The Basics of Scaling Analysis	183
6.3	Couette Flow Revisited with Nondimensionalization	189
6.4	Pressure-driven Flow with Nondimensionalization	194
6.5	Scaling the Incompressible Governing Equations	199
6.6	Incompressible Flow with a Compressible Fluid	205
6.7	Scaling to Obtain the Boundary Layer Equations	208
6.8	A Final Note	216
	Problems	218
	<i>Further Reading</i>	220
	<i>Index</i>	221