

# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
<b>2</b>	<b>Fluid Statics</b>	<b>23</b>
2.1	States of Matter	23
2.2	Pressure in Fluids at Rest	24
2.3	Buoyancy	29
2.3.1	Application of Buoyancy Principle to the Stability of a Ship	31
2.3.2	Balloons and Airships	32
2.3.3	Hydrostatics of Dam	33
2.4	Basics of Thermodynamics	36
2.4.1	Zeroth Law	37
2.4.2	Hydrostatics of Gases	37
2.4.3	Vapor Pressure	38
2.4.4	Internal Energy	40
2.4.5	Enthalpy	40
2.4.6	Specific Heats	41
2.4.7	Polytropic Form for Pressure-Specific Volume Relation	42
2.4.8	First Law of Thermodynamics	44
2.4.9	Adiabatic Process	45
2.4.10	Irreversible Process	45
2.4.11	Reversible Process	46
2.4.12	Entropy and Second Law of Thermodynamics	46
2.4.13	Entropy	47
2.4.14	Entropy Calculation for Any Process	48
2.4.15	Isentropic Process	49
<b>3</b>	<b>Fluid Dynamics</b>	<b>55</b>
3.1	Characteristics of Fluids	58
3.2	Mass Balance	60
3.3	Force Balance and Momentum Equations	62

3.4	Energy Equation . . . . .	65
3.5	Kinetic Energy . . . . .	69
3.6	Internal Energy . . . . .	69
3.7	Shear Stresses . . . . .	70
3.8	Equations of Motion . . . . .	71
3.9	Summary of Fluid Flow Equations . . . . .	72
<b>4</b>	<b>Finite Volume Method—Diffusion Problems . . . . .</b>	<b>75</b>
4.1	Diffusion Problem . . . . .	77
4.2	Diffusion with Source Term . . . . .	84
4.3	Diffusion with Convection . . . . .	90
<b>5</b>	<b>Finite Volume Method—Convection-Diffusion Problems . . . . .</b>	<b>99</b>
5.1	Steady State One-Dimensional Convection and Diffusion . . . . .	99
5.1.1	Exact Solution for Convection-Diffusion Problem . . . . .	102
5.1.2	Finite Volume Method for Convection-Diffusion Problem . . . . .	103
<b>6</b>	<b>Pressure—Velocity Coupling in Steady Flows . . . . .</b>	<b>107</b>
6.1	Steady State One-Dimensional Incompressible Problem . . . . .	108
6.1.1	Streamline Flow . . . . .	109
6.2	Pitot and Venturi Tubes . . . . .	111
6.3	Stagnation Conditions in Adiabatic Flow . . . . .	114
6.4	Isentropic Flow . . . . .	115
6.5	Speed of Sound . . . . .	116
6.6	Shocks in Supersonic Flow . . . . .	119
6.7	Other Forms of Energy Equation for Adiabatic Flow . . . . .	121
6.7.1	Mach Number for Which the Flow Can Be Considered Incompressible . . . . .	123
6.7.2	Characteristic Mach Number . . . . .	125
6.8	Quasi-One Dimensional Flow . . . . .	125
6.9	Area-Velocity Relation . . . . .	128
6.9.1	Continuity Equation in Differential Form . . . . .	128
6.9.2	Momentum Equation in Differential Form . . . . .	129
6.9.3	Energy Equation in Differential Form . . . . .	130
6.10	Example of Nozzle Flow—Subsonic Flow Throughout . . . . .	132
6.10.1	Example of Axisymmetric Nozzle Flow . . . . .	134
6.10.2	Subsonic Flow . . . . .	137
6.11	Nozzle Flow—Subsonic Flow with Sonic Conditions at the Throat . . . . .	140
6.12	Nozzle Flow—Supersonic Flow with Perfect Expansion . . . . .	142
6.13	CFD Solution of Isentropic Flow in Converging-Diverging Nozzles . . . . .	144

<b>7</b>	<b>Turbulence</b> . . . . .	155
7.1	What Is Turbulence? . . . . .	157
7.2	Reynolds Equations . . . . .	159
7.2.1	Reynolds Averaged Navier-Stokes Equations, RANS . . .	161
7.2.2	Boussinesq Hypothesis . . . . .	162
7.2.3	Prandtl's Mixing Length Model . . . . .	163
7.2.4	$k$ - $\varepsilon$ Model . . . . .	163
7.3	Nozzle Flow with a Normal Shock in the Divergent Portion . . .	166
7.3.1	Normal Shock . . . . .	166
7.4	CFD Solution of Flow in Converging-Diverging Nozzles with a Normal Shock . . . . .	175
<b>8</b>	<b>Epilogue</b> . . . . .	179
	<b>Index</b> . . . . .	181

Simulation Based Engineering in Fluid Flow Design

Rao, J.S.

2017, XV, 183 p. 102 illus., 62 illus. in color., Hardcover

ISBN: 978-3-319-46381-0