

CONTENTS

II EXPERIMENTAL AND COMPUTATIONAL FLUID DYNAMICS

15 Instrumentation for Fluid Dynamics	921
15.1 Random Error, Systematic Error, and Calibration	923
15.2 Methods of Data Analysis	931
15.3 Pressure Measurement	935
15.4 Velocity Measurement	961
15.5 Flow Rate Measurement	1002
15.6 Flow Visualization	1019
15.7 Flow Angle Measurement	1040
15.8 Forces and Moments	1042
15.9 Skin Friction Measurement	1048
15.10 Temperature and Heat Flux Measurement	1053
15.11 Vorticity Measurements	1064
15.12 Laser-Based Rayleigh and Mie Scattering	1084
15.13 Laser Raman Gas Diagnostics	1093
15.14 Laser Induced Gas Fluorescence	1096
15.15 Use of Computers for Data Acquisition and Processing	1098
References	1116
16 Fluid Dynamics Ground Test Facilities	1133
16.1 Introduction	1134
16.2 Tables of Facilities	1135
16.3 Aerodynamic Facilities	1136
16.4 Hydrodynamic Facilities	1148
16.5 Propulsion Test Facilities	1153
16.6 Special Facilities	1161
References	1167
17 Videotapes and Movies on Fluid Dynamics	1171
18 Introduction to Computational Fluid Dynamics	1191
18.1 Digital Computers for Fluid Dynamics Calculations	1191
18.2 Requirements for Calculation of Fluid Flows	1199
18.3 Multidisciplinary Computational Fluid Dynamics	1207
References	1214

19	Methods of Solving Fluid Dynamic Equations	1215
19.1	Grid Generation	1217
19.2	Finite Difference Methods	1257
19.3	Finite Element Methods	1272
19.4	Finite Volume Methods	1282
19.5	Time Accurate Approach	1308
19.6	Convergence Acceleration	1325
19.7	Adaptive Methods	1340
19.8	Fourier and Cyclic Reduction Methods for Poisson's Equation	1350
19.9	Spectral and Pseudo-Spectral Methods	1361
	References	1367
20	Computational Methods for Inviscid Flow	1385
20.1	Panel Methods	1386
20.2	Vortex Methods	1391
20.3	Numerical Treatment of Shock Waves	1404
20.4	Transonic Potential Methods	1407
20.5	Implicit Methods for the Euler Equations	1420
	References	1426
21	Computational Methods for Viscous Flow	1431
21.1	Physical Aspects of Computing Viscous Flow	1432
21.2	Analytical Aspects of Computing Viscous Flow	1462
21.3	Numerical Aspects of Computing Viscous Compressible Flow	1479
21.4	Navier–Stokes Equations for Incompressible Fluid Flow	1498
21.5	Numerical Simulation of Turbulence	1506
	References	1526
22	Computational Methods for Chemically Reacting Flow	1541
22.1	Introduction	1542
22.2	Thermodynamic Models	1543
22.3	Chemistry Models	1547
22.4	Governing Equations	1550
22.5	Space Discretization	1556
22.6	Time Integration	1571
22.7	Radiative Heat Transfer	1573
22.8	Shock Structure and Burnett Equations	1574
22.9	Biochemical Applications	1575
22.10	Numerical Results	1576
22.11	Concluding Remarks	1585
	References	1585