Copyright ©2007 by the Society for Industrial and Applied Mathematics
This electronic version is for personal use and may not be duplicated or distributed.

Contents

List of Figures **xi**

Preface **xv**

1 Fundamentals **1**
1.1 Notation . . . 1
1.2 Kinematics of a single particle . . . 2
1.3 Kinetics of a single particle . . . 3
1.3.1 Work, energy, and power . . . 3
1.3.2 Properties of a potential . . . 4
1.3.3 Impulse and momentum . . . 5
1.4 Systems of particles . . . 6
1.4.1 Linear momentum . . . 6
1.4.2 Energy principles . . . 7
1.4.3 Remarks on scaling . . . 8

2 Modeling of particulate flows **11**
2.1 Particulate flow in the presence of near-fields . . . 11
2.2 Mechanical contact with near-field interaction . . . 12
2.3 Kinetic energy dissipation . . . 15
2.4 Incorporating friction . . . 17
2.4.1 Limitations on friction coefficients . . . 18
2.4.2 Velocity-dependent coefficients of restitution . . . 19

3 Iterative solution schemes **21**
3.1 Simple temporal discretization . . . 21
3.2 An example of stability limitations . . . 22
3.3 Application to particulate flows . . . 22
3.4 Algorithmic implementation . . . 26

4 Representative numerical simulations **31**
4.1 Simulation parameters . . . 32
4.2 Results and observations . . . 33

From "An Introduction to Modeling and Simulation of Particulate Flows" by TI Zohdi.
Buy this book from SIAM at www.ec-securehost.com/SIAM/cs04.html.

Copyright ©2007 by the Society for Industrial and Applied Mathematics
This electronic version is for personal use and may not be duplicated or distributed.

5 Inverse problems/parameter identification 39
5.1 A genetic algorithm . . . 40
5.2 A representative example . . . 43

6 Extensions to "swarm-like" systems 47
6.1 Basic constructions . . . 48
6.2 A model objective function . . . 49
6.3 Numerical simulation . . . 50
6.4 Discussion . . . 52

7 Advanced particulate flow models 55
7.1 Introduction . . . 55
7.2 Clustering and agglomeration via binding forces . . . 55
7.3 Long-range instabilities and interaction truncation . . . 56
7.4 A simple model for thermochemical coupling . . . 58
7.4.1 Stage I: An energy balance during impact . . . 59
7.4.2 Stage II: Postcollision thermal behavior . . . 61
7.5 Staggering schemes . . . 63
7.5.1 A general iterative framework . . . 63
7.5.2 Semi-analytical examples . . . 66
7.5.3 Numerical examples involving particulate flows . . . 68

8 Coupled particle/fluid interaction 81
8.1 A model problem . . . 82
8.1.1 A simple characterization of particle/fluid interaction . . . 82
8.1.2 Particle thermodynamics . . . 84
8.2 Numerical discretization of the Navier–Stokes equations . . . 86
8.3 Numerical discretization of the particle equations . . . 89
8.4 An adaptive staggering solution scheme . . . 91
8.5 A numerical example . . . 95
8.6 Discussion of the results . . . 98
8.7 Summary . . . 101

9 Simple Optical scattering methods for particulate media 103
9.1 Introduction . . . 104
9.1.1 Ray theory: Scope of use . . . 104
9.1.2 Beams composed of multiple rays . . . 105
9.1.3 Objectives . . . 106
9.2 Plane harmonic electromagnetic waves . . . 107
9.2.1 Plane waves . . . 107
9.2.2 Electromagnetic waves . . . 107
9.2.3 Optical energy propagation . . . 108
9.2.4 Reflection and absorption of energy . . . 109
9.3 Multiple scatterers . . . 113
9.3.1 Parametrization of the scatterers . . . 114
9.3.2 Results for spherical scatterers . . . 116
9.3.3 Shape effects: Ellipsoidal geometries . . . 118

From "An Introduction to Modeling and Simulation of Particulate Flows" by TI Zohdi.
Buy this book from SIAM at www.ec-securehost.com/SIAM/cs04.html.

Copyright ©2007 by the Society for Industrial and Applied Mathematics
This electronic version is for personal use and may not be duplicated or distributed.

9.4 Discussion . . . 119
9.5 Thermal coupling . . . 120
9.6 Solution procedure . . . 122
9.7 Inverse problems/parameter identification . . . 124
9.8 Parametrization and a genetic algorithm . . . 125
9.9 Summary . . . 128

10 Closing remarks 133

A Basic (continuum) fluid mechanics 137
A.1 Deformation of line elements . . . 137
A.2 The Jacobian of the deformation gradient . . . 138
A.3 Equilibrium/kinetics of solid continua . . . 138
A.4 Postulates on volume and surface quantities . . . 139
A.5 Balance law formulations . . . 140
A.6 Symmetry of the stress tensor . . . 140
A.7 The first law of thermodynamics . . . 141
A.8 Basic constitutive assumptions for fluid mechanics . . . 142

B Scattering 145
B.1 Generalized Fresnel relations . . . 145
B.2 Biological applications: Multiple red blood cell light scattering . . . 145
B.2.1 Parametrization of cell configurations . . . 148
B.2.2 Computational algorithm . . . 148
B.2.3 A computational example . . . 149
B.2.4 Extensions and concluding remarks . . . 153
B.3 Acoustical scattering . . . 155
B.3.1 Basic relations . . . 155
B.3.2 Reflection and ray-tracing . . . 156

Bibliography 159

Index 175

From "An Introduction to Modeling and Simulation of Particulate Flows" by TI Zohdi.
Buy this book from SIAM at www.ec-securehost.com/SIAM/cs04.html.